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Quantitative projection of sukuk demand in Malaysia and the potential of sustainable sukuk to bridge expected supply-demand gap

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Abstract

Malaysia has firmly positioned itself as a prominent hub in Islamic finance, with sukuk (Shariah-compliant bonds) serving as a cornerstone of its financial ecosystem. This paper investigates the forecasting of long-term sukuk demand in Malaysia, a market that now surpasses the size of the domestic conventional bond market. Employing a quantitative approach based on historical bid-to-cover ratios from issued sukuk as benchmark, the study forecasts sukuk demand over a 10-year horizon and compares the projection against the anticipated sukuk supply. The paper also examines the potential of sustainable sukuk to bridge the expected demand-supply gap, amid their growing prominence in the market. The analysis is further contextualised by anecdotal evidence, including growing appetite from sizeable domestic institutional investors and emerging drivers that are expected to maintain the growth of sustainable sukuk such as alignment with national agenda. The findings aim to provide insights on the adequacy of current sukuk issuance rates in meeting future market demand.

Keywords: Malaysia, Islamic Finance, Sukuk, Islamic Bond, Demand-Supply Dynamics, Fixed Income Securities, Quantitative Forecasting, Sustainable Sukuk, Green Sukuk

JEL classification: C53, G12, G17, H63, Q56

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1. Introduction

Islamic finance has progressed from a niche alternative into an increasingly recognised component of the global financial landscape, driven by ethical imperatives and robust growth dynamics. Global Islamic finance assets reached about USD6 trillion in 2024, marking a notable 21 percent year-on-year growth, and are projected to rise to an estimated USD9.7 trillion by 2029 – underscoring the industry's sustained double-digit expansion despite prevailing market volatility (ICD-LSEG, 2025). This expansion reflects the industry's resilience and appeal: by emphasising risk-sharing structures, asset-backed instruments, and social welfare objectives, Islamic finance has attracted a diverse investor base seeking both stability and ethical alignment. Underpinning this growth is the *Maqāṣid al-Sharīʿah*[4] framework, which fulfills the higher objectives of Shariah – preserving religion (*dīn*), life (*nafs*), intellect (*'aql*), lineage (*nasb*), and wealth (*māl*)[5] and thus ensures that financial products promote communal well-being and justice rather than mere profit maximisation (Bin Bayyah, 2018).

At the forefront of this transformation stands Malaysia, which has retained the top position in the Islamic Finance Development Indicator (IFDI) 2025 for the 13th consecutive year (ICD-LSEG, 2025). As at end-July 2025, Malaysia's Islamic banking assets reached RM1,583.3 billion – 38.7 percent of total banking assets – while Islamic financing stood at RM997.7 billion, accounting for 47.5 percent of total loans and financing and growing by 8 percent year-on-year. Within the broader financial system, Malaysia's Islamic capital market has expanded to RM2,634 billion, representing about 64 percent of the domestic capital market, signalling the central role of Shariah-compliant intermediation in mobilising funds. This leadership is underpinned by robust Shariah governance as well as facilitative legal and regulatory frameworks that collectively position Malaysia as a principal incubator of Islamic financial innovation.

Within the dynamic Islamic financial markets, sukuk have emerged as the flagship instrument in meeting both public and private financing needs. Globally, outstanding sukuk surpassed approximately USD1 trillion in 2024, with annual sukuk issuance reaching USD254.3 billion and recording an 11 percent year-on-year increase, confirming sukuk's shift from a niche product to an increasingly mainstream funding tool (ICD-LSEG, 2025). Malaysia remains one of the world's largest sukuk markets, commanding an estimated 33.9 percent share of global sukuk outstanding as at end-July 2025. Domestically, sukuk amounts to RM1,402 billion, or 63.6 percent of Malaysia's outstanding debt securities. As sustainable finance gains traction worldwide, Malaysia has also pioneered sustainable sukuk[6], illustrating how sukuk can align Shariah objectives with environmental and social imperatives. Against this backdrop of robust growth and innovation, a detailed examination of demand-supply dynamics and the potential for sustainable sukuk to bridge emerging gaps is both timely and essential for policymakers and market participants.

[4] Higher Objectives of Islamic Law. Jurists such as al-Raysūni defined it as "the goals for which the Shariah was instituted in order to realise the welfare of His servants" (Muhammad Yusrī Ibrāhīm, 2013). Securities Commission Malaysia (2023) further contextualised this concept within the Islamic capital market (ICM) as an overarching, principle-based framework that goes beyond procedural Shariah compliance, emphasising the promotion of *maslahah* (human welfare) through the twin objectives of serving benefits and preventing harm (*jalb al-masālih wa dar' al-mafāsid*). In the ICM context, this is operationalised through six aspirations -Humanity; Justice and Benevolence; Clarity and Transparency; Flexibility and Innovation; Fiduciary and Accountability; Accessibility and Inclusivity -which guide financial activities towards equitable growth, ethical conduct, and sustainable socio-economic impact.

[5] Maqāṣid al-Sharīʿah for wealth category are influenced by five elements: circulation, clarity, preservation, establishment, and justice.

[6] Sustainable sukuk include Sustainable and Responsible Investment (SRI) and SRI-linked sukuk as outlined by Securities Commission Malaysia and ASEAN Green, Social, Sustainability and Sustainability-linked Bond as outlined by ASEAN Capital Market Forum (ACMF). Much like in the European Union, these frameworks are very much aligned with United Nations Sustainable Development Goals (SDG).

2. Literature Review

Foundational Insights on Sukuk

Sukuk, derived from the Arabic word for *certificate,* in its simplest form are certificates of equal value that evidence undivided ownership or investment in the assets based on Shariah principles and concepts[7]. Sukuk are structured to avoid interest (*ribā*), uncertainty (*gharar*) and speculation (*maysir*) – key prohibitions in Islamic finance. Sukuk serve as Islamic capital market instruments designed to meet the financing needs of fund seekers, including government and corporations that require large-scale Shariah-compliant funding. Sukuk have been documented as an effective tool for resource mobilisation (Jobst et al., 2008); they are often structured to mimic the economic outcome of fixed income instrument such as bonds, offering regular returns to investors and repayment of principal at maturity. The main reason for this convergence to bond-like instruments - considering similar risk-reward structures and features - is that the bond market plays a pivotal role in the broader financial markets and economy (Bahari et al., 2016, Sairally et al., 2017). Nonetheless, as the sukuk market develops and matures, its features have evolved to include distinct characteristics, particularly through the adoption of various financial contracts tailored to diverse economic needs across different regions of the world. For example, sale-based sukuk (based on the contract of *Murābaḥah*, *Salam*, *Istisnāʿ*), lease-based sukuk (based on the concept of *Ijārah*), partnership-based and agency (based on the concept of *Muḍārabah*, *Mushārakah* and *Wakālah*), or any combination thereof. Further innovation introduces capacity sukuk, which utilises 'business capacity' of respective companies (such as airtime by telcos, rights to travel by airlines) as intangible underlying assets (Djafri et al., 2023). Table 1 provides further details on the foundational differences between conventional bond and sukuk.

Comparison between bond and sukuk instruments — Table 1

Aspect	Bond	Sukuk
Nature	Represent interest-bearing debt obligation of the issuer	Represent proportionate ownership in Shariah compliant assets, usufructs, services, or profit-sharing venture or financial asset, or any combination
Issuer	Any issuer	Any issuer engaged in business activities which are permissible under Shariah rulings
Investor base	Conventional	Islamic and conventional investors
Issuer-investor relationship	Debtor-creditor	Sale, lease, partnership, agency or combination
Returns to investors	Interest on loan	Profit from sale, rent from lease, profit sharing from investment activities/service
Principal repayment by issuer	Return of principal at maturity is irrevocable, regardless of the profitability of funded project	In sale-based and lease-based structures, the return of principal is guaranteed. However, in principle, there is no ex-ante fixed obligation of capital repayment for partnership-based sukuk structure
Underlying assets	Not applicable	Shall comply with Shariah requirements, can represent both debt and non-debt assets.
Utilisation of proceeds	No specific requirements	Proceeds must be utilised to finance Shariah-compliant activities

[7] Definition by Malaysia's Securities Commission. In the Malaysia, the Shariah principles and concepts shall be endorsed by the Securities Commission's Shariah Advisory Council.

Pricing	Pricing based on credit rating of issuer and term and conditions, usually a spread over a reference interest rate	Pricing depends on the structure of the sukuk. For non-recourse asset-backed sukuk, pricing is based on the asset. For sukuk structured based on fixed income and debt-creating contracts, pricing is typically similar to bond pricing.
Tradability	Sale of debt	Dependent on the nature of underlying assets

Sukuk are now issued in multiple currencies across the globe. They have become increasingly mainstream in their traditional homes in the Middle East (e.g. Saudi Arabia, UAE, Turkiye, Iran, Qatar, Bahrain, Kuwait) and Southeast Asia (e.g. Malaysia, Indonesia), while also expanding into non-traditional markets such as the United Kingdom, France, Luxembourg, Hong Kong, South Africa and the United States.

Brief History of Sukuk Development in Malaysia

Malaysia's sukuk journey began with the issuance of the Government Investment Certificate (GIC) in 1983, aimed at providing an avenue for short-term liquidity management and long-term investment for Islamic financial institutions during the period. These were later replaced by Malaysian Government Investment Issues (MGII), laying the foundation for the development of the domestic Islamic capital market. The first corporate sukuk was later issued in Malaysia in 1990 by Shell MDS Malaysia (Sairally et al., 2017). Several decades later, Malaysia's sukuk market has grown exponentially and has demonstrated a positive impact on economic growth (Abrorov, 2020). Sukuk have been instrumental in financing major infrastructure projects in Malaysia, including commuter and rapid transit system, airports, highways and buildings. Notably, Merdeka 118, Malaysia's most recent skyscraper and the second tallest building in the world, was also funded through sukuk.

Malaysia is the ideal dataset for this study, hosting a mature Islamic capital market alongside the conventional bond market. This dual financial system, governed by the Financial Services Act (2013) and the Islamic Financial Services Act (IFSA) 2013, enables a fair and meaningful comparison between the two vibrant markets.

Recent Studies on Sukuk Forecasting

In the sukuk and Islamic finance forecasting literature, time-series models such as ARIMA and its seasonal variant SARIMA are widely used as baseline benchmarks before moving to more complex specifications. For example, Rosadhillah and Ülev (2024) forecast Turkey's sovereign sukuk outstanding with ARIMA and then examine its relationship with inflation and the exchange rate using Granger causality, Their study is useful for the present paper because it treats sukuk outstanding as a time-series object whose own past dynamics must first be modelled before macro-financial linkages are assessed. However, since their model is ARIMA rather than SARIMA/SARIMAX, it is best read as support for the univariate benchmark stage.

Seasonal and calendar-sensitive extensions are relevant where monthly or quarterly financial series display recurring patterns. In Islamic economies, this is especially important because religious-calendar and business-cycle effects can affect financial and monetary series. Riazuddin and Khan (2005) worked on extending standard ARIMA modelling to incorporate Islamic calendar effects in monthly currency-in-circulation in Pakistan and found that such effects were strongly pronounced. This supports the broader rationale for testing seasonal structures before adding further macro-financial variables, especially where issuance and investment activity may be influenced by recurring fiscal, religious or corporate funding windows.

A second strand of the literature uses causality testing to identify whether macroeconomic variables contain genuine predictive content for sukuk markets. The methodological foundation is Toda and Yamamoto (1995), whose augmented VAR approach allows inference in levels even when variables may be integrated or cointegrated. In sukuk-specific applications, Echchabi, Aziz and Idriss (2016) applied the Toda–Yamamoto Granger non-causality test to major sukuk-issuing countries and found evidence of directional causality running from sukuk to GDP and gross capital formation in the pooled sample, although not for Saudi Arabia and the GCC separately. More recently, Baykut (2024) applied the Toda–Yamamoto causality test to Turkish sukuk data and showed that the dollar exchange rate and deposit interest rates have causal relationships with the size of sukuk issuance, while ARDL model is used to quantify short- and long-term relationships of sukuk returns with respect to other macroeconomic variables. Together, these studies justify a design where causality testing is positioned between a univariate benchmark and a multivariate forecasting model, serving as an econometrically robust filter for selecting macro-financial drivers.

Once candidate drivers are identified, another body of work moves from univariate ARIMA/SARIMA to multivariate time-series models with exogenous regressors - ARIMAX/SARIMAX, ARDL, VAR and related frameworks - to improve forecast accuracy. In Islamic banking, Aryani, Aidi, and Syafitri (2018) used ARIMAX and regression with ARIMA errors approaches to relate Islamic bank profitability to macroeconomic predictors such as benchmark interest rate, inflation and exchange rates. The result was noted vigilantly as its reported model performance comparison did not provide a clean general claim that ARIMAX always outperforms ARIMA.

Parallel to these econometric developments, a growing literature experiments with machine-learning and hybrid models to capture potential non-linearities in sukuk and Islamic-finance series. Hila et al. (2019), for instance, studied sukuk investment forecasting using artificial-neural-network-based algorithms and report lower forecast errors than those obtained from simple moving-average benchmarks, highlighting the ability of ANN architectures to pick up complex patterns in sukuk returns. Çetin and Metlek (2021) applied a multilayer feed-forward ANN to to forecast Turkish sovereign sukuk prices with dollar index, volatility index, geopolitical risk index, S&P MENA sukuk index and Eurobond prices as input variables. These studies show the potential of machine-learning models in sukuk forecasting, but they also highlight a trade-off: whilst ANN-based models may capture complex patterns, they are less transparent than SARIMA/SARIMAX specifications when the purpose is to explain the role of macro-financial drivers in a policy-oriented setting.

Taken together, the literature supports a stepped methodological strategy for sukuk demand–supply analysis. First, a SARIMA model can be used to establish a transparent baseline forecast that captures own-dynamics and seasonality in sukuk demand or sukuk supply, following common practice in sukuk and macro-financial forecasting. Second, Toda–Yamamoto causality testing can be employed – following the logic of Toda and Yamamoto (1995), Echchabi, Aziz and Idriss (2016), and Baykut (2024) - to screen macro variables and identify those with statistically significant causal influence on sukuk series. Third, a SARIMAX specification can be estimated that embeds only the causally relevant macroeconomic drivers, thereby preserving the parsimony and interpretability of SARIMA whilst allowing selected exogenous variables to improve conditional projections. This sequence provides a literature-anchored rationale for moving from SARIMA to TY-MWALD screening, followed by SARIMAX in a sukuk supply-demand forecasting framework.

3. Methodology

Data Collection and Consideration

This study uses monthly open-tender issuances of Malaysian sukuk and conventional bonds from 2000Q1 to 2025Q2, combined with quarterly macro-financial variables.

We focus on open-tender auctions, which account for about 46% of Malaysia's debt securities market. Open tenders provide market-driven prices and quantities, as a broad investor base competes on yields and allocation, thus providing "true" demand for ringgit sukuk and bonds. By contrast, private placements are negotiated bilaterally with a select group of investors and may be influenced by multiple factors such as relationship between dealers, information asymmetries, negotiation dynamics, or national-interest considerations. Open tender issuances by sovereign issuers establish the reference yield curve, which serves as a common benchmark for pricing privately placed instruments of similar tenor. Taken together, these factors make open tender issuances a more reliable proxy for overall market conditions.

The dataset originates from Malaysia's Fully Automated System for Issuing/Tendering (FAST), a local system that facilitates primary issuance of all debt securities instruments which is accessible through public platforms such as Bond Pricing Agency Malaysia (BPAM) Bondstream application and various industry market reports. The final dataset comprises 869 open-tender issuances across diverse sectors. Of these, 655 are sovereign and 214 are corporate issues, and within the same sample, 491 instruments are conventional bonds while 378 are Shariah-compliant sukuk. This construction allows us to compare sukuk and conventional bonds, and sovereign and corporate segments, under a common auction mechanism.

To explain and forecast sukuk demand–supply dynamics, we link these issuance data to a set of macro-financial covariates. Malaysia's benchmark interest rate, Overnight Policy Rate (OPR), is taken from Bank Negara Malaysia's official data download and captures the monetary-policy stance; it is available from 2004 onwards, so regressions that include OPR naturally begin later than the full sukuk/bond sample. The 12-month fixed-deposit rate of commercial banks is obtained from government record, OpenDOSM, and Bank Negara Malaysia's published statistics, and measures the opportunity cost of holding deposits relative to sukuk and bonds. The USD-Malaysian Ringgit (MYR) exchange rate comes from the Federal Reserve Bank of St. Louis (FRED series DEXMAUS) and reflects external conditions and currency risk that may affect foreign participation in Malaysia's debt markets.

We proxy domestic risk sentiment and relative asset attractiveness using the Malaysia's benchmark stock market index, FTSE Bursa Malaysia KLCI (FBMKLCI, via Investing.com). FDI inflows, outflows and net flows are drawn from OpenDOSM's balance-of-payments data and capture external financing conditions and real-sector investment. Conventional bond demand and supply, which are a part of the overall dataset, provide a direct conventional benchmark for sukuk demand and supply. Finally, we require a long, consistent measure of the domestic business cycle. For 2015Q1–2025Q2, we use official quarterly real GDP at constant prices from OpenDOSM. For 2000Q1–2014Q4, where quarterly real GDP is not available in a directly usable form, we construct a model-based quarterly series using an unrestricted mixed data sampling (U-MIDAS) regression anchored to annual real GDP growth from the World Bank.

The resulting quarterly GDP growth series thus combines observed data (2015 onward) with U-MIDAS-based backcasts (pre-2015). We use the extended series primarily as a control for the macroeconomic cycle; key results are checked against the shorter post-2015 sample where quarterly GDP is fully observed.

Assumptions

In addition, the forecast relies on several broad assumptions. It presumes a stable political and policy environment over the next decade, with no major policy reversal or regulatory changes that could drastically disrupt the Malaysia's financial market. This includes the continuity of Shariah regulations and governance, whereby the current centralised Shariah authority called the Shariah Advisory Council (SAC) remains intact. Economic growth and benchmark interest rate are assumed to follow a historically predictable path within the range of 1.75%-3.50% and exclude the occurrence of any black swan events that could trigger global market shocks. Non-resident holdings of Ringgit-denominated sukuk, which currently averaged around 3.6% of outstanding sukuk and remained lower than conventional counterparts, are assumed to stay broadly unchanged over the next 10 years, consistent with historical pattern. The forecast does not factor in potential upsides from increased foreign participation that may result from ongoing market initiatives to attract foreign funds into the domestic market.

Diagnostics, Forecast Techniques and Variable Screening

Model diagnostics and differencing

We first determine the order of differencing required to obtain a stationary representation of sukuk demand and supply. This is necessary because SARIMA and SARIMAX models require the stochastic component of the series to be stationary after the appropriate non-seasonal and seasonal transformations.

(a) Unit-root and stationarity tests

We use the Augmented Dickey–Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests as complementary checks on stationarity. The ADF test uses a unit-root null hypothesis, whilst the KPSS test uses a stationarity null hypothesis. Taken together, both tests provide a more reliable basis for identifying the integration order of the series.

Augmented Dickey-Fuller (ADF) test

For a series y_t, the ADF regression is specified as:

$$\Delta y_t = \alpha + \beta t + \phi y_{t-1} + \sum_{i=1}^{p} \psi_i \Delta y_{t-i} + \varepsilon_t$$

where $\Delta y_t = y_t - y_{t-1}$, t is a deterministic time trend, and p is the number of augmentation lags included to account for serial correlation in the residuals. If the deterministic trend is not included, the term βt is omitted. The hypotheses are:

- Null: $H_0: \phi = 0$ (unit root, non-stationary).
- Alternative: $H_1: \phi < 0$
  (stationary or trend-stationary, depending on deterministic specification)

Rejection of H_0 indicates that the series being tested does not contain a unit root under the selected deterministic specification.

Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test

The KPSS test takes the opposite null: that the series is level- or trend-stationary. Let $\hat{u}_t$ denote the residuals from this regression, and define the partial sum process as:

$$S_t = \sum_{i=1}^{t} \hat{u}_i$$

The KPSS statistic is:

$$KPSS = \frac{1}{T^2\hat{\sigma}^2}\sum_{t=1}^{T} S_t^2$$

where T is the sample size and $\hat{\sigma}^2$ is a consistent estimate of the long-run variance of $\hat{u}_t$. Large values of the statistic lead to rejection of the stationarity null.

Using ADF together with KPSS allows the integration order to be triangulated. ADF tests whether the series contain a unit root, whereas KPSS tests whether the series is stationary around the relevant deterministic component. This combined approach motivates the non-seasonal differencing decision, while the seasonal differencing decision is supported separately by monthly plots, autocorrelation functions and residual diagnostics.

Results:

- In levels, both sukuk demand and sukuk supply display strong persistence and upward trends. Under the relevant deterministic specifications, the ADF tests fail to reject the unit-root null at conventional levels, while KPSS tests reject the stationarity null. This provides evidence that both series are non-stationarity in levels.
- In first differences, the ADF tests reject the unit-root null and the KPSS tests no longer reject stationarity for both series.

Taken together, these outcomes indicate that both sukuk supply and sukuk demand are integrated of order one, $I(1)$, justifying one non-seasonal difference ($d = 1$) in all subsequent SARIMA and SARIMAX models.

(b) Seasonal behaviour and residual autocorrelation

Monthly plots and autocorrelation functions show a pronounced 12-month seasonal pattern in both sukuk demand and sukuk supply. To address this seasonal structure, we apply a seasonal difference at period $s = 12$:

$$\nabla_{12} y_t = (1 - B^{12}) y_t,$$

where B is the backshift operator, so that:

$$B^{12} y_t = y_{t-12}$$

and therefore:

$$\nabla_{12} y_t = y_t - y_{t-12}$$

The combined non-seasonal and seasonal differencing transformation is:

$$\omega_t = (1 - B)(1 - B^{12}) y_t$$

where $(1 - B)$ applies the first non-seasonal difference and $(1 - B^{12})$ applies the seasonal difference. This corresponds to:

$$d = 1, \qquad D = 1, \qquad s = 12$$

For the pure SARIMA specification, this transformation is applied to the endogenous issuance series. In the SARIMAX specification, the same integration orders are imposed on the endogenous series, whilst the treatment of exogenous regressors follows the selected SARIMAX framework.

After differencing, we examine the residual autocorrelation using Ljung-Box Q statistic:

$$Q(m) = n(n+2)\sum_{k=1}^{m}\frac{\hat{p}_k^2}{n-k}$$

where n is the sample size, $\hat{p}_k$ is the residual autocorrelation at lag k, and m is the maximum lag tested. The null hypothesis is that there is no residual autocorrelation up to lag m. For fitted SARIMA and SARIMAX models, the statistic is assessed with degrees of freedom adjusted for the estimated dynamic parameters.

Results:

- The combined non-seasonal and seasonal differencing transformation, ($d = 1,\ D = 1,\ s = 12$), removes visible seasonality from both sukuk series.
- For candidate SARIMA models estimated on ω_t, Ljung–Box tests at lags 12 and 24 do not reject the null of no residual autocorrelation for sukuk demand and sukuk supply, indicating that the differenced models capture the main dynamics of the series and do not leave systematic autocorrelation in the residuals.

(c) Order selection via information criteria

Among the differenced models, parsimonious lag orders are selected using the Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC):

$$\mathrm{AIC} = -2\hat{\ell} + 2k$$

$$\mathrm{BIC} = -2\hat{\ell} + k\ln n$$

where $\hat{\ell}$ is the maximised log-likelihood, k the number of estimated parameters, and n is the effective sample size. Lower values of AIC and BIC indicate a better balance between model fit and parsimony, with BIC applying a stronger penalty for additional parameters.

Results:

- For both sukuk demand and sukuk supply, the information criteria favour low-order MA dynamics with no non-seasonal AR terms, and a single seasonal MA term at lag 12.
- The preferred specification that balances fit and parsimony for both sukuk demand and sukuk supply in both SARIMA and SARIMAX is $(0,1,2)(0,1,1)_{12}$.

Main forecasting technique: SARIMA and SARIMAX

Let y_t denote the sukuk demand or sukuk supply. Using the backshift operator B, where $By_t = y_{t-1}$, the non-seasonal and seasonal differences are defined as follows:

- $\nabla y_t = (1-B)y_t$
- $\nabla_s y_t = (1-B^s)y_t$

For monthly data, $s = 12$, so that:

$$\nabla_s y_t = (1-B^s)y_t = y_t - y_{t-12}$$

The differencing structure and order selection identified in the diagnostic stage are then carried over when exogenous variables are added in the SARIMAX models. This ensures that the sukuk demand and sukuk supply equations share a common, well-diagnosed time-series backbone, whilst allowing macro-financial drivers to enter the forecasting framework.

Seasonal Autoregressive Integrated Moving Average (SARIMA)

A general Seasonal ARIMA model, SARIMA $(p,d,q)(P,D,Q)_s$ can be written as:

$$\Phi(B)\Phi_s(B^s)(1-B)^d(1-B^s)^D y_t = \Theta(B)\Theta_s(B^s)\varepsilon_t$$

where:

- $\Phi(B) = 1 - \phi_1 B - \cdots - \phi_p B^p$ is the non-seasonal AR polynomial;
- $\Phi_s(B^s) = 1 - \Phi_1 B^s - \cdots - \Phi_P B^{P_s}$ is the seasonal AR polynomial;
- $\Theta(B) = 1 + \theta_1 B + \cdots + \theta_q B^q$ is the non-seasonal MA polynomial;
- $\Theta_s(B^s) = 1 + \Theta_1 B^s + \cdots + \Theta_Q B^{Q_s}$ is the seasonal MA polynomial;

and ε_t is a white-noise error.

This framework captures short-term persistence, seasonal patterns and shocks in a single, relatively parsimonious structure.

SARIMA with exogenous regressors (SARIMAX)

To quantify how macro-financial drivers affect issuance, we extend the model to include exogenous variables. The SARIMAX model can be represented as a regression with SARIMA errors:

$$y_t = \beta' x_{t-1} + u_t$$
$$\Phi(B)\Phi_s(B^s)(1-B)^d(1-B^s)^D u_t = \Theta(B)\Theta_s(B^s)\varepsilon_t$$

where x_{t-1} is a vector of lagged, standardised exogenous variables (e.g. OPR, 12-month fixed-deposit rate, 10-year Malaysian Government Securities (MGS) yield, conventional bond demand and bond supply, USD/MYR, quarterly real GDP growth), and the vector β contains the associated coefficients. Lagging x_t by one period aligns the regressors with the information set available at auction time and reduces simultaneity concerns. SARIMAX therefore preserves the interpretability of SARIMA while allowing the marginal contribution of macro-financial drivers to be assessed in the sukuk and bond demand and supply equations.

Model-agnostic directionality screening: Toda-Yamamoto MWALD

We screen candidate drivers using the Toda–Yamamoto (TY) modified Wald causality test. The TY approach has two advantages:

- It can be applied to variables that may be integrated or cointegrated, provided the maximum order of integration is accounted for;
- and it enables standard Wald-type inference by by estimating an augmented VAR in levels.

Let $Z_t = (y_t, x_t)'$ stack sukuk demand/supply with a candidate macro-variable (e.g. OPR). We estimate the lag-augmented VAR:

$$Z_t = c + \sum_{i=1}^{k+d_{max}} A_i Z_{t-i} + u_t$$

where k is the optimal lag length of the underlying VAR in levels, d_{max} is the maximum suspected integration order among the variables, and u_t is a vector of innovations.

To test whether x_t Granger-causes y_t, we test the joint null hypothesis that the coefficients on the first k lags of x_t in the y_t equation are zero. The additional d_{max} lags are included to secure the asymptomatic distribution of the test statistic but are not included in the causality restrictions.

Let $\hat{\beta}$ be the stacked VAR coefficient vector and R the restriction matrix such that $R\beta = 0$ encodes the null hypothesis of "no causality from $x_t$to y_t". The TY modified Wald statistic is:

$$W = (R\hat{\beta})'[R\widehat{Var}(\hat{\beta})R']^{-1}(R\hat{\beta})$$

which is asymptotically distributed as $W \sim \boldsymbol{\chi}_{\boldsymbol{q}}^{\boldsymbol{2}}$ under the null, with q as the number of restrictions.

For each candidate macro variable, a bivariate TY test is conducted with sukuk (or bond) demand/supply. Variables that exhibit statistically significant unilateral or bilateral causality are retained as exogenous regressors in the SARIMAX models; variables that do not are excluded. This model-agnostic screening helps ensure that only predictive directional content are fed into the final forecasting equations.

Forecast-accuracy metric: Mean Absolute Scaled Error (MASE)

To compare forecast performance across sukuk and bond models, we use the Mean Absolute Scaled Error (MASE) proposed by Hyndman and Koehler (2006). MASE is scale-free and is therefore suitable for comparing forecast accuracy across series with different magnitude.

For a seasonal monthly series with period $s = 12$, let $e_t = y_t - \hat{y}_t$ denote the forecast error. The in-sample mean absolute error of the seasonal naïve benchmark as:

$$MAE_{\text{naïve}} = \frac{1}{T-s}\sum_{t=s+1}^{T}|y_t - y_{t-s}|$$

where the seasonal naïve benchmark forecast is:

$$\hat{y}_t^{\text{naïve}} = y_{t-s}$$

and the absolute scaled errors is:

$$q_t = \frac{|e_t|}{MAE_{\text{naïve}}}$$

thus, the MASE over a forecast horizon of length H is:

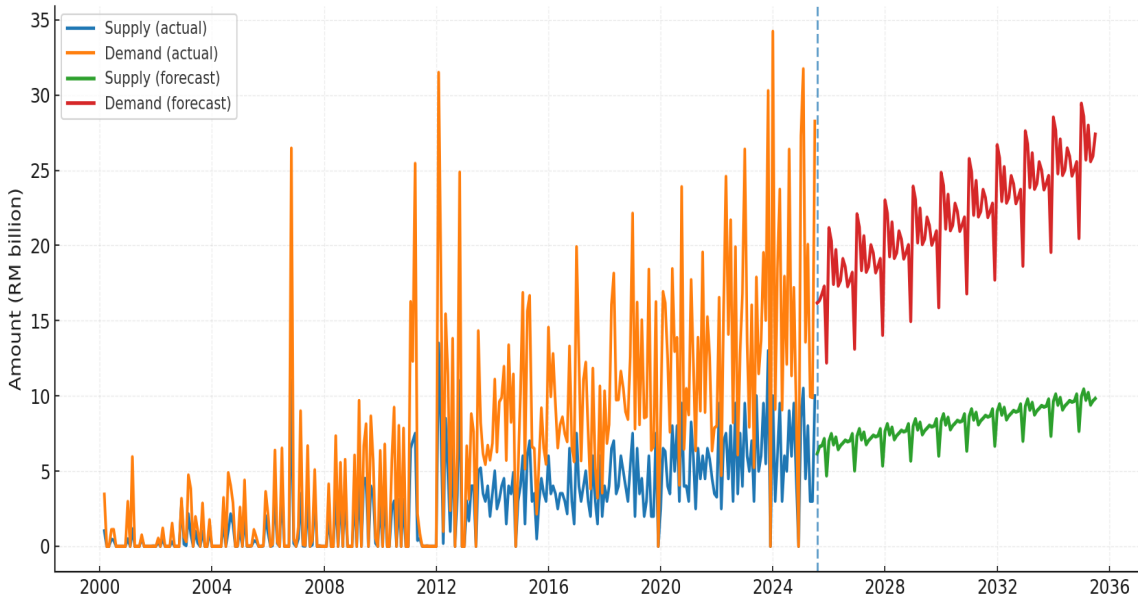
$$MASE = \frac{1}{H}\sum_{t=1}^{H}|q_t|.$$

Values below one indicate that a model improves on the seasonal naïve benchmark, and values above one indicate weaker forecast performance than the seasonal naïve benchmark.

4. Preliminary Results

Seasonal Autoregressive Integrated Moving Average (SARIMA)

SARIMA baseline forecast for sukuk issuance supply-demand (2025-2035) Chart 1



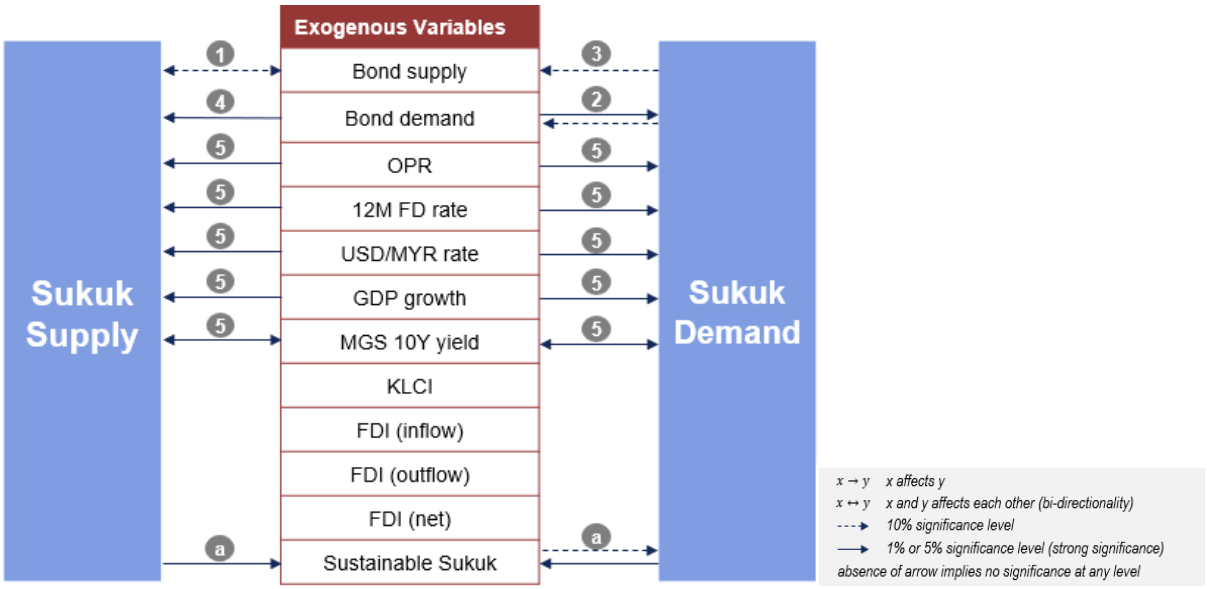
As a first step, sukuk supply and demand are modelled separately using a univariate Seasonal ARIMA specification. Based on the diagnostics in Section 4.1, we apply one non-seasonal and one seasonal difference at period 12, and select a low-order MA structure. The resulting baseline for both sukuk supply and sukuk demand is SARIMA(0,1,2)(0,1,1)$_{12}$. The intercept is set to zero; the transformed series fluctuates around zero without an imposed deterministic drift after differencing, therefore the forecasts are driven purely by the estimated stochastic components.

Using this SARIMA specification, we generate 10-year forecasts for sukuk supply and sukuk demand. The model produces a constant BTC stabilising at about 2.78 over both horizons at the end of 5-year and 10-year forecast. In other words, the purely endogenous SARIMA model effectively assumes that sukuk demand will scale proportionally with sukuk supply, yielding a constant auction coverage ratio.

To judge whether this baseline is adequate, we evaluate in-sample fit using the Mean Absolute Scaled Error (MASE) relative to a seasonal naïve benchmark y_{t-12}, following Hyndman and Koehler (2006). For sukuk supply, MASE ≈ 1.41, and for sukuk demand, MASE ≈ 1.58; these results show that the univariate SARIMA does not fully capture the dynamics of sukuk supply and demand. Taken together the constant BTC around 2.78 and MASE > 1 for both series, this motivates extending the model to include exogenous macro-financial variables. In the next step, these candidate drivers are screened using the Toda–Yamamoto modified Wald (TY-MWALD) causality tests, and the selected variables are incorporated in a SARIMAX framework.

Toda-Yamamoto Modified Wald Test (TYMWALD test)

Directionality of variables via TYMWALD test — Chart 2



To justify the choice of regressors, we use bivariate Toda–Yamamoto modified Wald (TY-MWALD) causality tests between each candidate external variable and sukuk supply and sukuk demand. For every pair (y_t, x_t) where y_t is sukuk supply or demand and x_t is a candidate driver, we estimate a lag-augmented VAR in levels with maximum integration order set to one and then test, via the MWALD statistic, whether lags of x_t jointly Granger-cause y_t. Variables that exhibit statistically significant causality at conventional levels are retained as exogenous regressors in the SARIMAX models; those that do not are excluded.

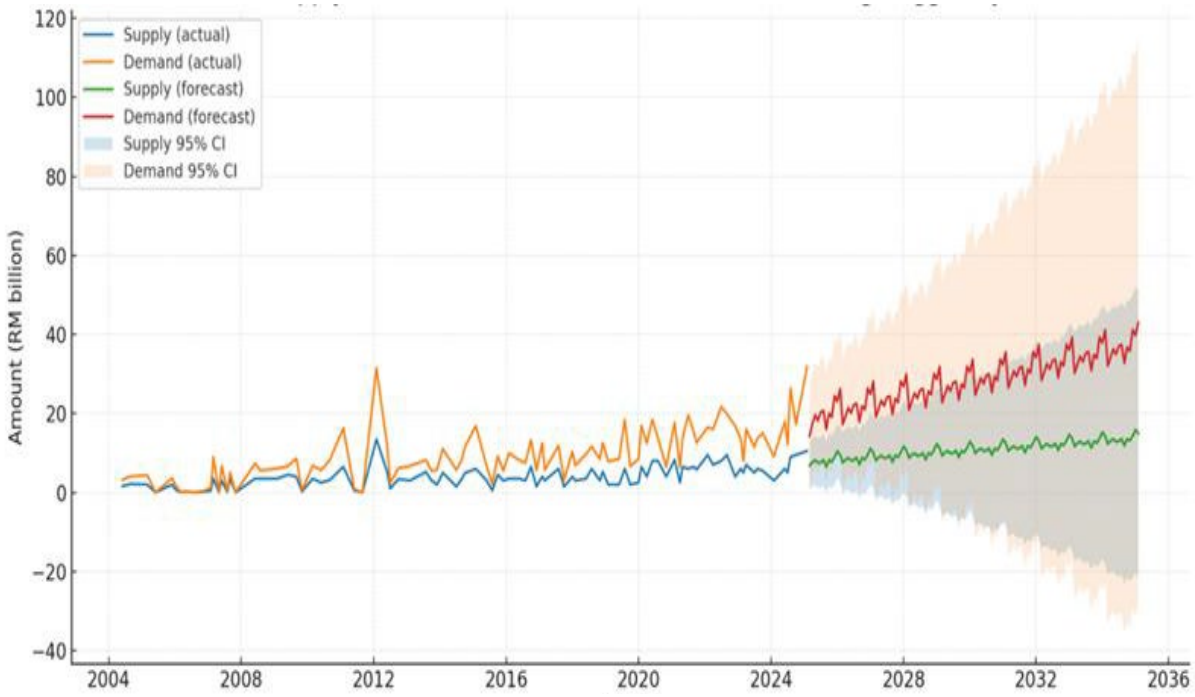
The tests show strong mutual dependence between sukuk and conventional markets. Sukuk supply and bond supply Granger-cause each other, as issuance in one segment often prompt adjustments in the other. Similarly, sukuk demand and bond demand are mutually causal, reflecting portfolio rebalancing tendencies between sukuk and conventional bonds. There is also unidirectional spillover from sukuk demand to bond supply (interpretable as investors' preference for Shariah-compliant instruments influencing funding choices and reducing bond issuance) and from bond demand to sukuk supply (conventional investors are also able to buy sukuk, so swings in bond demand transmit to more sukuk issuance).

Among the macro-financial variables, the TY-MWALD tests support the benchmark interest rate OPR, the 12-month fixed-deposit rate, the USD/MYR exchange rate, quarterly real GDP growth and the 10-year MGS yield. All aforementioned indicators show predictive content for sukuk supply and sukuk demand, with particularly strong bi-directional causality between sukuk variables and the 10-year MGS yield, underlining the benchmark role of long-term government instrument yields. An additional variable, sustainable sukuk issuance, is found to Granger-cause sukuk demand and to be itself influenced by sukuk demand and supply, though it is ultimately excluded from the forecasting equations because the available data start only in 2017, creating a much shorter and structurally different sample than the main dataset (from 2000). By contrast, the FTSE KLCI index and FDI measures (inflow, outflow and net) show no robust causal link with sukuk supply or demand in the TY-MWALD tests and are therefore excluded. The final

SARIMAX models for sukuk supply and sukuk demand thus include only the external variables for which the TY-MWALD procedure provides clear evidence of predictive power.

5. Analysis

SARIMAX forecast on Malaysian Sukuk Issuance Supply-Demand (2025-2035) Chart 3



Note: Both sukuk supply and demand are modelled using SARIMAX(0,1,2)(0,1,1)$_{12}$ with exogenous variables (MGS10Y, OPR, 12-month FD rate, USD/MYR, quarterly real GDP YoY, conventional bond supply and bond demand) lagged one month and standardised on the training window (2004-09 till 2025-02) due to absence of OPR data from 2000-early 2004.

Building on the SARIMA backbone, we estimate SARIMAX(0,1,2)(0,1,1)$_{12}$ models for sukuk demand and sukuk supply, adding exogenous variables selected through the TY-MWALD screening procedure. The SARIMAX model is specified as a regression with SARIMA errors:

$$y_t = \beta' Z_{t-1} + u_t$$

$$(1-B)(1-B^{12})u_t = \theta(B)\Theta(B^{12})\,\varepsilon_t$$

where y_t denotes sukuk demand or sukuk supply, Z_{t-1} is the lag-1 standardised vector of exogenous variables, and u_t is the regression error component that follows the selected seasonal ARIMA structure.

The exogenous vector is given by:

$$Z_{t-1} = [MGS10Y_{t-1}, OPR_{t-1}, FD_{t-1}, FX_{t-1}, QGDP_{t-1}, Bond\ D_{t-1}, Bond\ S_{t-1}]'$$

with $\theta(B) = 1 + \theta_1 B + \theta_2 B^2$ and $\Theta(B^{12}) = 1 + \Theta_1 B^{12}$. All exogenous variables are lagged by one period to better match the information set available at issuance time and to reduce simultaneity concerns.

The SARIMAX forecasts indicate a widening gap between projected sukuk demand and supply over 2025–2035. Conditional on the assumed macro-financial paths, demand for ringgit-denominated

sukuk is projected to roughly triple by 2035, with the point forecast reaching about RM42 billion and the upper bound of the forecast interval approaching RM100 billion in more favourable scenarios. By contrast, sukuk supply is expected to grow only gradually. As a result, the forecast bid-to-cover (BTC) ratio, defined as forecast demand over forecast supply, rises from around 2.10 times in 2025 to about 2.89 times by 2035, implying a widening demand–supply gap and intensifying competition among investors for Shariah-compliant paper.

Model diagnostics suggest that the inclusion of exogenous drivers delivers improved forecast performance relative to the univariate SARIMA baseline. Residual Ljung–Box tests at lags 12 and 24 do not reject the null of no autocorrelation, indicating that the SARIMAX specifications adequately capture remaining serial dependence. Using MASE relative to the seasonal naïve benchmark y_{t-12}, the average scaled errors fall below one for both series (0.898 for sukuk supply and 0.885 for sukuk demand), showing that the SARIMAX models now outperform the seasonal naïve benchmark and improve on the earlier SARIMA fits. Overall, the results suggest that macro-financial conditions, particularly the benchmark interest rate, long-term government yields, deposit rates, exchange rate movements, GDP growth, as well as conventional bond market conditions contain useful predictive information for realistic projections of Malaysia's future sukuk demand–supply balance.

Scenario-unit coefficient of exogenous variables — Chart 4

Dependent Variable	Scenario-Unit Impact	Exogenous Variable	Scenario-Unit Impact	Dependent Variable
Sukuk supply	+ RM2.18 bn	Bond supply (+RM10 bn)	+ RM4.95 bn	Sukuk Demand
	+ RM0.25 bn	Bond demand (+RM10 bn)	+ RM0.33 bn	
	+ RM0.77 bn	OPR (+25 bps)	+ RM1.10 bn	
	- RM2.68 bn	12M FD rate (+25 bps)	- RM5.17 bn	
	+ RM0.36 bn	USD/MYR rate (+0.10 USD appreciates)	+ RM0.89 bn	
	+ RM0.12 bn	GDP growth (+ 1.0 pps)	+ RM0.30 bn	
	- RM0.82 bn	MGS 10Y yield (+ 50 bps)	- RM1.33 bn	

Note: Exogenous variables are standardised using training-window means and standard deviations before estimation. The reported values convert the standardised SARIMAX coefficients into scenario-unit effects using $\hat{\beta}_j^{(z)}\left(\frac{\Delta x_j}{\sigma_j}\right)$*, where* Δx_j *is the reported change in the original variable. The estimates show the model-implied change in the transformed monthly sukuk issuance series,* $\omega_t = (1-B)(1-B^{12})y_t$*, associated with selected changes in each lagged driver, holding other regressors constant. These coefficient effects should be interpreted as conditional predictive associations rather than structural causal impacts.*

The pattern of SARIMAX coefficients is consistent with how sukuk behave in the wider fixed-income literature. First, the positive coefficients on sukuk supply and demand to conventional bond supply and demand reflects that both instruments tap a common pool of investors and are often priced off similar benchmarks. Event-study and portfolio studies show that markets tend to treat sukuk and conventional bonds as closely related claims: stock-price reactions to sukuk and bond announcements are similar across various situations (Godlewski, Turk-Ariss & Weill, 2011; Alam, Hassan & Haque 2013), and adding sukuk to conventional bond portfolios mainly reshapes, rather than transforms, the risk–return profile (Raei & Çakır, 2007). This supports our interpretation that stronger overall fixed-income appetite, captured by higher conventional bond supply and demand, raises issuance and demand for sukuk rather than crowding them out.

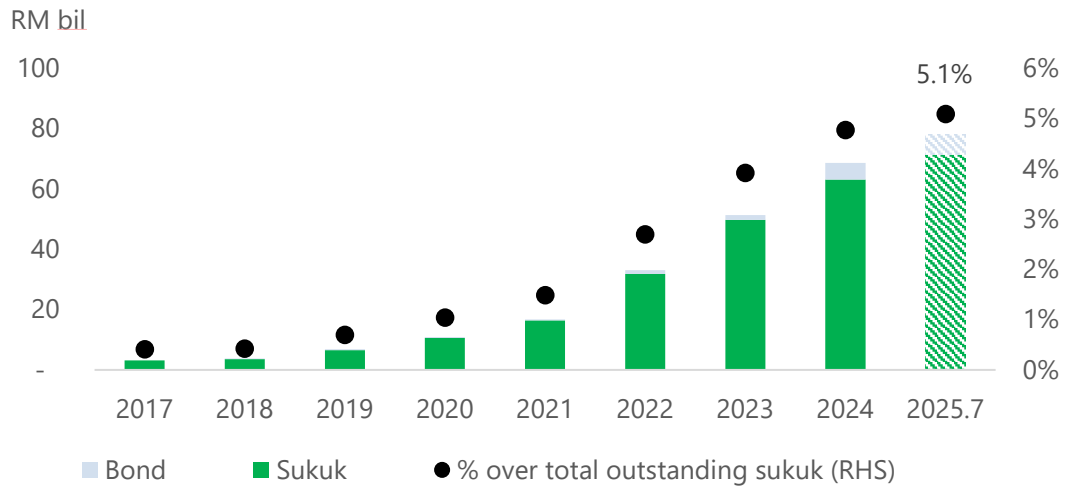
Second, the negative coefficients on 12-month fixed deposit rates and long-term government yields on sukuk issuance and demand is in line with evidence that higher interest-rate levels or wider interest-rate spreads dampen sukuk market development due to weaker issuance appetite and lower investor risk appetite, particularly to longer tenor instruments. Cross-country GMM studies find that larger interest-rate spreads (lending minus deposit or interbank rates) are significantly and negatively related to sukuk market size, as higher borrowing costs deter new issues (Said & Grassa, 2013; Smaoui & Khawaja, 2017). Conceptual models for GCC countries similarly highlight interest rates as a key macro factor shaping sukuk financing decisions (Al-Raeai, Zainol, & Abdul Rahim, 2018). Our finding that increases in the benchmark interest rate OPR are associated with modestly higher sukuk activity fits this logic: short-term policy tightening lifts expected yields, making new sukuk relatively more attractive than existing papers, even as very high long-term or deposit rates eventually restrain issuance and demand.

Third, the positive coefficients on GDP growth accord with the broader literature that links larger or faster-growing economies to deeper sukuk markets. Empirical work shows that economic size and income per capita are among the strongest predictors of sukuk market development (Smaoui & Khawaja, 2017; Basyariah, Kusuma & Qizam, 2021; Najib & Sa'adah, 2025), as stronger growth generates more investment projects and supports domestic investor bases. Studies on the growth effects of sukuk also find that sukuk market development and real GDP growth reinforce one another over the long run (Smaoui & Nechi, 2017; Yıldırım, Yıldırım & Diboglu, 2020), consistent with our interpretation that higher contemporaneous GDP growth goes hand in hand with higher sukuk issuance and demand.

Finally, the positive coefficient on ringgit depreciation (higher USD/MYR) on ringgit sukuk activity is consistent with research that emphasises exchange rate and currency-risk channels in both sukuk and local-currency bond markets. Cross-country studies identify the exchange rate and its volatility as significant determinants of sukuk market development, often with adverse effects when currency risk is high (Said & Grassa, 2013; Basyariah, Kusuma & Qizam, 2021; Al-Raeai et al., 2018). At the same time, BIS and IMF work on emerging-market local-currency bond markets shows that exchange-rate movements strongly influence local-currency bond risk premia and can encourage borrowers to shift away from foreign-currency borrowing to avoid balance-sheet mismatches (Burger & Warnock, 2006; Hofmann, Shim, & Shin, 2020; Grigorian, 2019). Taken together, these findings support our reading that a weaker ringgit heightens FX risk and encourages both issuers and investors to favour local-currency, Shariah-compliant sukuk.

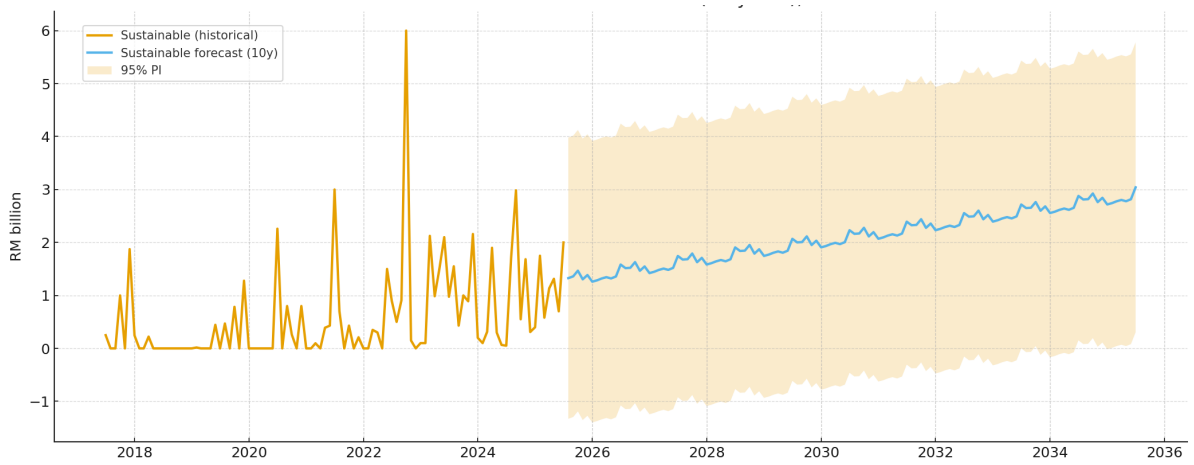
6. Potential of Sustainable Sukuk to Fill the Demand-Supply Gap

Malaysia's outstanding sustainable debt securities (2017-2025) Chart 5



Earlier, the study presented a forecast estimate that the demand-supply gap of Malaysia's sukuk to widen in the coming 10 years. At the same time, the study also observed that sustainable sukuk growth is rapidly expanding in the Malaysia's market, presenting timely opportunities to bridge the stated gap. The market share is currently still minimal at 5.1% of the overall outstanding domestic debt securities market, yet 5-year CAGR shown impressive growth of 57%.

SARIMA Sustainable sukuk forecast (2025-2035) Chart 6



Though MASE value is 1.26, SARIMA is proven the best forecasting model compared to others (e.g. ARIMA, Holt-Winter method etc.) for the particular dataset. Earlier diagnostics confirmed its model to be SARIMA $(0,1,2)(0,1,1)_{12}$.

The same forecast model is then utilised to estimate the projection of sustainable sukuk growth, and the finding suggests that if Malaysia's market managed to sustain this growth in the same 10-year

period, sustainable sukuk is estimated to reach RM3.04 billion – sufficient to plug earlier estimated demand-supply gap of RM2.95 billion. The estimate however is ambitious due to severely limited time horizon since the first ever sustainable sukuk was issued in 2017[8], giving merely 8-years data for the forecast. Nonetheless, the presence of multiple growth drivers in the Malaysia's domestic market signals that the current momentum could be maintained. The drivers include:

1. **Alignment with national agenda** – with Malaysia's clear target and commitment to achieve net-zero emission by 2050. The government have also identified the necessary infrastructure and initiatives through climate roadmaps (e.g. National Energy Transition Roadmap, NETR) and the required funding to operationalise the plan. The market is foreseeing high potential for these initiatives to be funded by sustainable sukuk, judging from wide availability, familiarity to the instrument and proven track records.

2. **Facilitative regulatory landscape** – the financial sector authorities are actively providing conducive ecosystem to sustainable sukuk to thrive, including tax incentives, capacity building programmes and issuance of frameworks & industry guides.

3. **Integration of ESG into investment mandate** - institutional investors, domestic and foreign, are increasingly integrating ESG into their investment strategy and mandate, in line with the growing awareness on climate risks and social equity.

4. **Broader range of issuers** – which includes multilateral development banks, local councils, corporates. Notably, an education institution in Malaysia has ventured to issue green sukuk in 2018 to construct a solar power plant and transmission infrastructure.

Beyond these market and policy drivers, sustainable sukuk also has a deeper normative basis within Islamic finance. Quran 30:41 warns about human-induced corruption (*fasād*) in the created order, "Corruption has spread on land and sea as a result of what people's hands have done, so that He/We[9] may cause them to taste the consequences of some of their deeds and perhaps they might return to the Right Path". Al-Farrā' (2006) exegeted *fasād* in this context as encompassing drought on land and the drying up of resources at sea as a consequence of humanity's misconduct, whereby hardship in this world functions as a corrective prompt to repentance. In contemporary terms, this linkage between moral failure, environmental disruption and economic hardship provides a theological rationale for designing instruments such as sustainable sukuk that actively mitigate environmental damage and support social well-being, rather than amplifying the deterioration caused by unsustainable patterns of production and consumption.

In this light, the projected expansion of Malaysia's sustainable sukuk market is not merely a market-based funding solution, but part of a wider call to reverse corruption by directing capital towards projects that restore balance (*iṣlāḥ*)[10] in society and the environment. This aligns with MIFC Leadership Council's aspiration where Islamic finance is expected to generate positive and sustained impact on lives, livelihoods, economics and societies. By financing renewable energy, low-carbon infrastructure and socially beneficial projects, sustainable sukuk contribute to a mode of development that is more consistent

[8] https://www.sukuk.com/article/malaysia-launches-the-worlds-first-green-sukuk-6361/

[9] Among the ten canonical recitations (*Qira'at*), two authentic readings for the word لِيُذِيقَهُمْ refer to the interchangeability of God's pronouns "He" and "We" (لِنُذِيقَهُمْ) both complying with the standardised Uthmani script; the former (most of the reciters) keeps the third-person flow of the surrounding verses and emphasises on the occurrence of the consequences itself; the latter (read by Qunbul from Ibn Kathīr in one form and Rauḥ from Yaʿqūb) expresses God speaking about Himself in the plural of grandeur, heightening the sense of justice and the greatness of the Divine act. Both readings converge on the same meaning: the hardship and corruption people experience on Earth is a divinely governed consequence of their own wrongdoings, intended to cue their return to righteousness. Refer to Ibn Ghalbūn (2017); Muhannā, (2022), and Sanad (2023) for more details.

[10] Refer to MIFC Leadership Council (2024) Position Paper, "Establish Islah through Islamic Finance". https://mifclc.com/main/wp-content/uploads/2024/06/MIFC_Position-Paper.pdf

with the Quranic vision of responsible human agency on earth, while remaining fully integrated with the broader sukuk market architecture.

7. Challenges and opportunities

i. **Inconsistency in sukuk issuance data frequency** – monthly sukuk issuances is not consistently available. Within the 25-year dataset, there were months of nil issuance. Impairment of consistent data pattern could adversely impact the robustness of forecasts and accuracy of predictions.

ii. **Limitations on sustainable sukuk forecast** – dataset horizon is severely limited. Sustainable sukuk was only first issued in 2017, compared to the overall sukuk dataset available from early 21st century. Its limited data timeline renders it incompatible with the overall SARIMAX model. Sustainable sukuk are also currently offered exclusively through private placement, which necessitates its exclusion from the overall sukuk forecast.

iii. **Limited benchmarking on sukuk issuance forecasting** – There are limited studies conducted on forecasting of sukuk in both industry and academia. This gap underscores the need for more rigorous research and data-driven analysis to establish benchmarks and improve predictive methodologies in the sukuk market.

8. Conclusion

Sukuk demand in Malaysia is forecasted to triple within the next decade, and expected to widen the existing demand-supply gap as well as increase competition among investors seeking for the Shariah-compliant investment instrument in the domestic market.

The study finds SARIMA is inadequate to project the forecast accurately, hence necessitating exogenous variables in the said projection through SARIMAX. The study also incorporates exogenous variables including conventional bonds supply and demand, benchmark interest rate OPR, 12-month fixed deposit rate by commercial banks, USD-MYR exchange rate, quarterly GDP growth and MGS 10-year yield.

Anecdotal evidence is also supportive of the forecast, with expectations of growing appetite from major institutional investors with Shariah-compliant investment mandates. For example, Malaysia's Employees Provident Fund (EPF) – the 5th largest pension fund in Asia – recorded an 11% increase in contribution size driven by wage growth and an increased workforce size.[11]

Nevertheless, sustainable sukuk is forecasted to bridge the demand-supply gap within the same period, should the current rapid growth rate be sustained. The estimate is supported by multiple drivers in the Malaysia's market, such as alignment with national agenda, facilitative regulatory support, enhanced integration of ESG considerations into investment strategies and institutional investors' mandates as well as broader range of issuers in the sustainable sukuk segment.

[11] https://www.kwsp.gov.my/en/w/epf-declares-630-dividend-for-simpanan-konvensional-and-630-for-simpanan-shariah-In

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10. Annex

Constructing a long quarterly GDP series using U-MIDAS adapted annual benchmarking

Official quarterly real GDP for Malaysia is available only for the more recent period. To avoid discarding early sukuk and bond observations, we extend quarterly GDP series back to 2000Q1 using U-MIDAS adapted annual benchmarking.

The procedure is adapted from U-MIDAS literature, rather than applied as textbook U-MIDAS nowcasting model because the task is to backcast a higher-frequency quarterly GDP path from lower-frequency annual information. We therefore use the unrestricted lag structure of U-MIDAS as a transparent bridge equation, while annual consistency is imposed through a separate benchmarking step. The U-MIDAS framework, developed by Foroni, Marcellino and Schumacher (2011), is useful in this context as it allows mixed-frequency relationships to be modelled without imposing restrictive lag-polynomial assumptions. In our setting, , by assigning unrestricted coefficients to each lag. In our case, we let $GDP_{q,t}$ denote quarterly real GDP growth and $GDP_{a,\tau}$ denote annual real GDP growth. For the period where both official quarterly and annual growth rates are available, we estimate the following bridge equation:

$$GDP_{q,t} = \alpha + \sum_{j=0}^{K} \beta_j GDP_{a,\tau(t)-j} + \varepsilon_t$$

where $\tau(t)$ maps quarter t to its corresponding calendar year, $GDP_{a,\tau(t)-j}$ denotes appropriately aligned annual real GDP growth and its lags, and β_j are freely estimated lag coefficients. The model is estimated by ordinary least squares using the period where quarterly GDP data are available. The estimated coefficients are then applied to annual GDP growth observations for 2000-2014 to generate preliminary quarterly GDP growth backcasts for 2000Q1 – 2014Q4.

Because an unrestricted bridge regression does not automatically guarantee that the generated quarterly path aggregates consistently to the observed annual growth rates, we impose a separate annual benchmarking step. This ensures that the backcast quarterly series preserves the official annual macroeconomic path, while the intrayear quarterly profile is informed by the relationship estimated over the period where quarterly GDP data are available. The resulting quarterly GDP growth series therefore extends the macroeconomic control variable back to 2000Q1 without discarding early sukuk and bond observations, whilst maintaining consistency with observed annual GDP growth.

Why MASE is preferred and not RMSE / MAPE?

Hyndman and Koehler (2006) introduced scaled errors and proposed MASE as a general-purpose accuracy for comparing forecast performance across different time series. The idea is to normalise each model's forecast errors by the in-sample MAE of a simple benchmark (here, the seasonal naïve benchmark), so that:

- **Scale-free comparability**. Because both the numerator and denominator are in the same units, MASE is independent of scale and can be used to compare forecast accuracy across series (e.g. sukuk vs bonds, demand vs supply) that differ in level and volatility.
- **Robustness with zeroes and intermittent data**. Percentage-based measures such as MAPE or sMAPE divide by actual values and can become undefined or unstable when observations are near or close to zero. MASE avoids this problem because the scaling denominator is based on the in-sample absolute error of the benchmark forecast, except in unusual cases where the benchmark error is exactly zero.

- **Clear interpretation relative to a realistic benchmark**. Using the seasonal naïve as the reference makes interpretation straightforward:
    - MASE < 1: better than seasonal naïve benchmark;
    - MASE = 1: no gain over seasonal naïve benchmark;
    - MASE > 1: worse than seasonal naïve benchmark.
- **Support in the forecasting literature.** Subsequent work (e.g. Franses, 2016) shows that MASE integrates well within formal tests of equal forecast accuracy and behaves better than several alternative criteria in simulations, reinforcing its status as a recommended standard when comparing forecasting methods.

Interpreting SARIMAX coefficients and scenario-unit effects

SARIMAX as regression with ARIMA errors

In this setting, the SARIMAX model is interpreted as a regression model with seasonal ARIMA errors:

$$y_t = \beta_0 + \beta' Z_{t-1} + u_t$$
$$(1-B)(1-B^{12})u_t = \theta(B)\Theta(B^{12})\,\varepsilon_t$$

where y_t denotes monthly sukuk demand or supply, Z_{t-1} is the vector of lagged exogenous variables, and u_t is the regression error component following the selected seasonal ARIMA structure.

The specification follows the dynamic-regression treatment of SARIMAX as regression with ARIMA errors, where the regression component captures the conditional association between the sukuk issuance and the lagged exogenous regressors, whilst the ARIMA component models serial dependence in the regression errors (Hyndman & Athanasopoulos, 2021). This is also consistent with the state-space SARIMAX implementation in *statsmodels*, which treats exogenous variables OLS-type regressors within a regression within SARIMA errors framework (Seabold & Perktold, 2010).

Standardising exogenous variables and recovering "scenario-unit" effects

For numerical stability and comparability, the SARIMAX models are estimated with standardised exogenous variables,

$$z_{j,t-1} = \frac{x_{j,t-1} - \mu_j}{\sigma_j}$$

in which μ_j and σ_j are the training-window mean and standard deviation of exogenous variable x_j. The estimated coefficient $\hat{\beta}_j^{(z)}$therefore measures the model-implied change in y_t measured in RM billion, associated with one standard deviation change in x_j, holding other regressors constant and accounting for the seasonal ARIMA error structure. This is consistent with the standard regression-scaling logic that dividing predictors by their standard deviations places heterogenous variables on a common scale, though such scaling does not by itself establish causal interpretation (Gelman, 2008).

Because standardisation is a linear transformation, the implied original-scale coefficient is:

$$\hat{\beta}_j^{(original\ scale)} = \frac{\hat{\beta}_j^{(z)}}{\sigma_j}$$

yet Chart 4 reports effects for selected economically meaningful changes, hence the applied reported quantity is scenario-unit effect:

$$\widehat{Scenario\ effect}_j(\Delta x_j) = \hat{\beta}_j^{(z)}(\frac{\Delta x_j}{\sigma_j})$$

Δx_j is the selected change in the original variable, such as as +25 basis points in OPR" or +RM10 billion in conventional bond supply on sukuk issuance. This use of standardised exogenous variables is appropriate when SARIMAX/ARIMAX models include heterogenous macro-financial predictors measured in different units, such as interest rates, exchange rates, GDP growth and currency denominations. The reported values should therefore be interpreted as conditional, model-implied scenario-unit effects, not structural causal impacts. Recent applied SARIMAX/ARIMAX forecasting studies incorporate diverse exogenous information into their forecasting frameworks; Lei, Chen, and Chu (2025) used SARIMAX model for gaming tourism destination demand by incorporating heterogeneous external information such as gaming revenue, weather, transportation, exchange rates, holidays and seasonality. Vonitsanos, Kanavos, and Mylonas (2025) similarly developed a context-enriched ARIMAX-deep learning framework for Bitcoin price forecasting, market capitalisation and moving averages to enrich the model inputs.

Quantitative Projection of Sukuk Demand in Malaysia and The Potential of Sustainable Sukuk to Bridge Expected Supply-Demand Gap

Muhammad Nadzif bin Ramlan and Abdul Haq bin Mohaidin
Bank Negara Malaysia

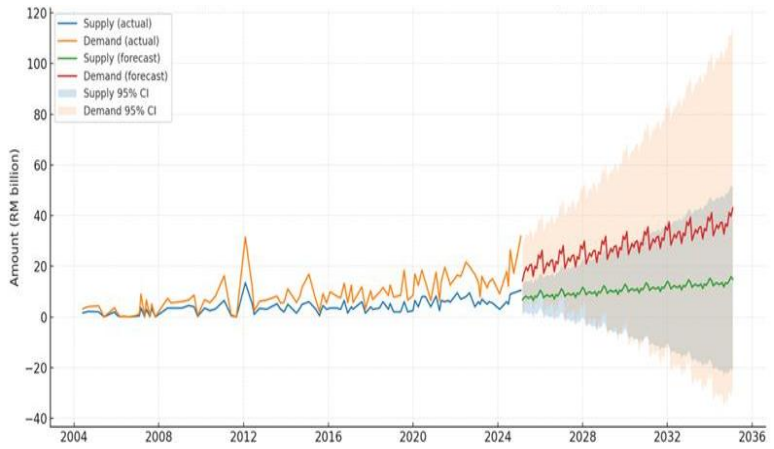
Seminar by De Nederlandsche Bank (DNB) and the BIS's Irving Fisher Committee (IFC)
Sustainability data issues and central banks' experience
Amsterdam, Netherlands
4 October 2025

The views expressed in this presentation are those of the authors and not necessarily those of Bank Negara Malaysia.

Executive summary: Demand for Malaysia's sukuk forecasted to triple in the next decade, widening existing demand-supply gap

Sukuk demand projected to triple by 2035

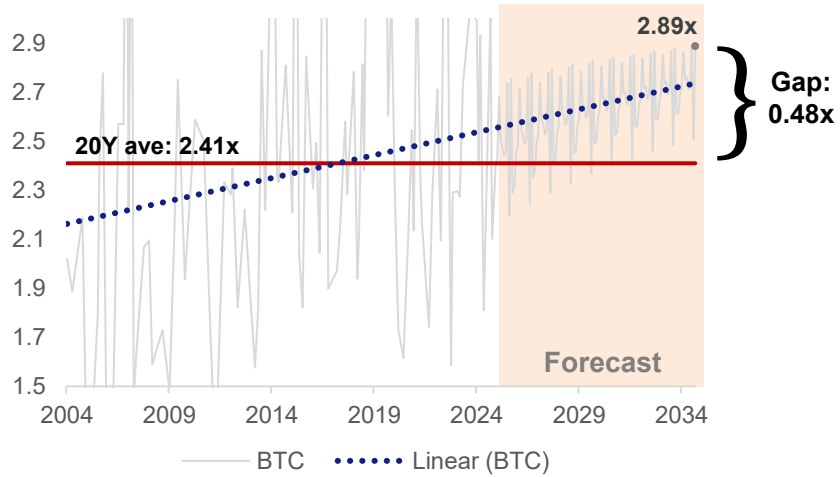
Malaysia's sukuk issuance supply-demand forecast (2025-2035)



Demand for Ringgit-denominated sukuk is projected to triple in size to RM42 billion by 2035. In contrast, demand for conventional bonds is expected to moderate during the same period. Tested and utilised forecast models include Seasonal Autoregressive Integrated Moving Average (SARIMA), Toda-Yamamoto Modified Wald Test (TY-MWALD) and SARIMA with exogenous variables (SARIMAX).

Widening the demand-supply gap even further

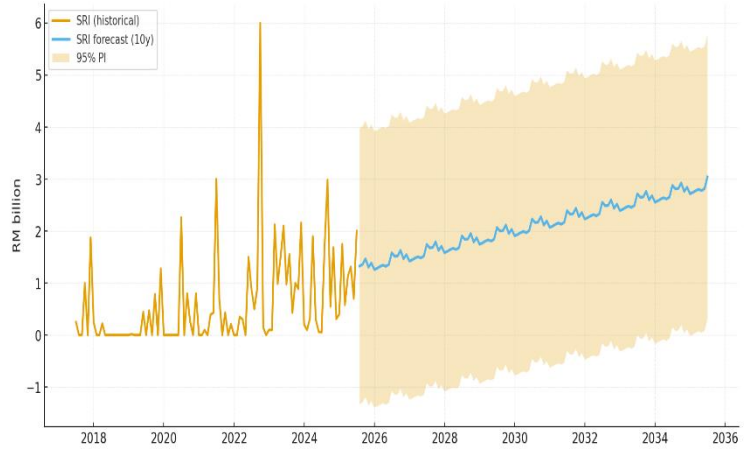
Malaysia's sukuk bid-to-cover ratio (2004-2035)



Sukuk bid-to-cover ratio (BTC) expected to rise higher than 20-year average (2.41x), as demand outpaces supply. This signals increasing competition among investors for limited Shariah-compliant sukuk issuances.

Nevertheless, sustainable sukuk could bridge the expected gap

Malaysia's sustainable sukuk issuances forecast (2025-2035)



Should sustainable sukuk maintain its current rapid growth, the issuance is forecasted to reach up to RM3 billion in the next same period of 10 years, sufficient to address the projected demand-supply gap (BTC 0.48x, or RM2.95 billion). BTC will gravitate back towards 20Y average if this materialise.

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Other forecast: ICD-LSEG's Islamic Finance Development Report 2024 forecasts that global sukuk is set to grow at 12% (CAGR 2023-2028). Similarly, our model forecasts sukuk issuances (sukuk supply green line in LHS chart) to grow at 12% (5Y CAGR).

Sustainability definition: Malaysia is mainly guided by Securities Commission Malaysia's Sustainable and Responsible Investment (SRI) Framework 2019 that are aligned with United Nations Sustainable Development Goals (SDGs). The EU similarly adopted the SDGs through its Taxonomy Regulation 2020, setting out overarching conditions for bonds to qualify as environmentally sustainable.

Presentation Outline

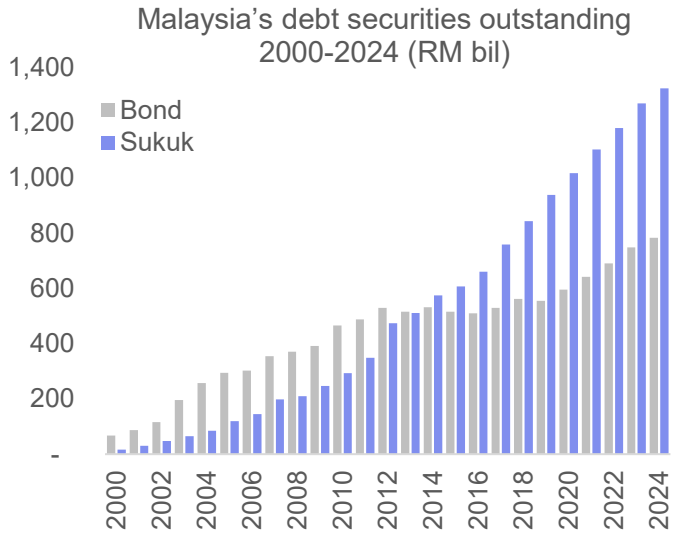
1. Introduction
2. Methodology
3. Analysis: Forecast findings
4. Analysis: Sustainable sukuk to bridge the gap
5. Limitations and Challenges
6. Conclusion

Appendices

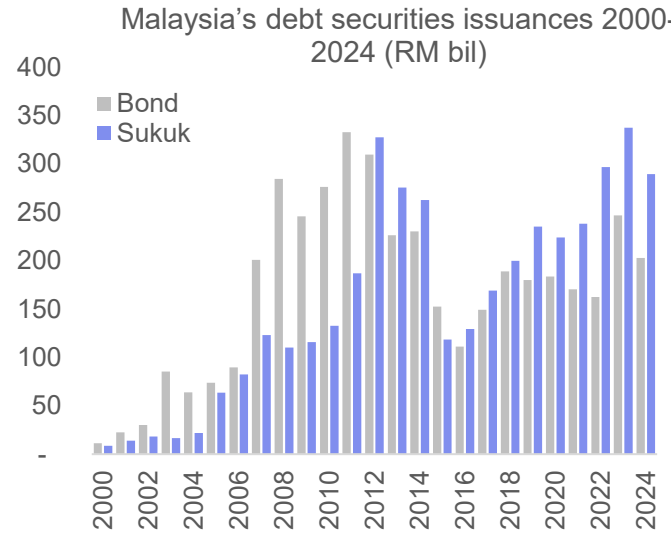
1. Literature review
2. Dataset and assumptions
3. Comparison with bond

Introduction: Islamic finance in Malaysia

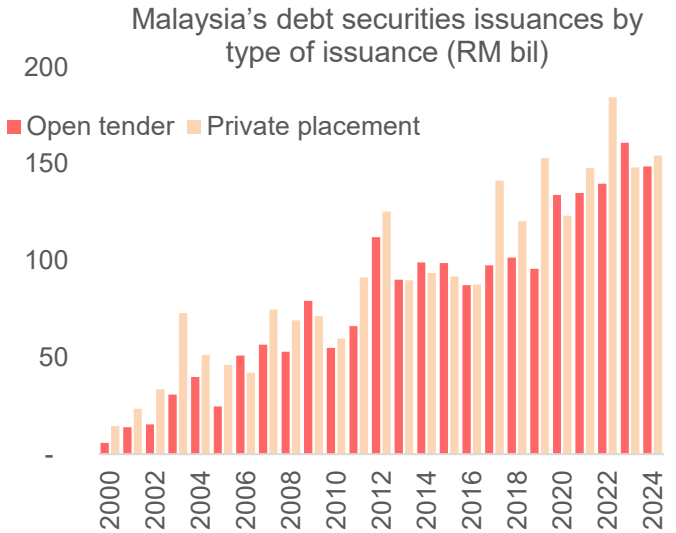
- Islamic finance has evolved from a niche alternative into a cornerstone of the global financial system, driven by ethical imperatives and robust growth dynamics. Underpinning this growth is the **Maqaṣid al-Sharīah (**higher objectives of Islamic law): preserving religion (*dīn*), life (*nafs*), intellect (*'aql*), lineage (*nasb*), and wealth (*māl*); objectives within wealth are five – circulation, clarity, preservation, establishment, and justice (Bin Bayyah, 2018).
- Globally, the Islamic financial services industry – covering capital market, banking and takaful – experienced growth in 2024, achieving a strong 14.9% year-on-year increase and reaching total assets of USD3.88 trillion; of which global outstanding sukuk surpassed USD900 billion (Islamic Financial Services Board, May 2025).
- Malaysia is home to the most developed Islamic finance market, ranked first globally for 12th consecutive year by the Islamic Finance Development Indicator (IFDI) 2024 released by ICD-LSEG. For sukuk market in particular, Malaysia has the largest share in the global market at 33.2% as at end-July 2024 (Ministry of Finance Malaysia, 2024).
- Within its unique dual financial system where Islamic and conventional system run in parallel, Islamic market comprised approximately 64% of Malaysia's domestic capital market (Securities Commission Malaysia, 2025), and anticipated to maintain its growth momentum—a trend observed since the early 21st century.



CAGR (2000-2024): Bond 10.8%; Sukuk 20.3%



CAGR (2000-2024): Bond 12.8%; Sukuk 15.7%



CAGR (2000-2024): Open tender 14.5%; private placement 10.3%

Introduction: Comparison between sukuk and conventional bonds

Sukuk industry has dominantly advanced in Malaysia's dual financial system, despite structural differences in comparison to conventional bonds:

Bond	Aspect	Sukuk
Represent interest-bearing debt obligation of the issuer	**Nature**	Represent proportionate ownership in Shariah compliant assets, usufructs, services, or profit-sharing venture or financial asset, or any combination
Any issuer	**Issuer**	Any issuer engaged in business activities which are permissible under Shariah rulings
Conventional	**Investor base**	Islamic and conventional investors
Debtor-creditor	**Issuer-investor relationship**	Sale, lease, partnership, agency or combination
Interest on loan	**Returns to investors**	Profit from sale, rent from lease, profit from investment activities/service
Return of principal at maturity is an irrevocable, irrespective profitability of funded project	**Principal repayment by issuer**	In sale-based and lease-based structures, the return of principal is guaranteed. However, in principle, there is no ex-ante fixed obligation of capital repayment for partnership-based sukuk structure
Not applicable	**Underlying assets**	Shall comply with Shariah requirements, can represent both debt and non-debt assets.
No specific requirements	**Utilisation of proceeds**	Proceeds must be utilised to finance Shariah-compliant activities
Pricing based on credit rating of issuer and term and conditions, usually a spread over a reference interest rate	**Pricing**	Pricing depends on the structure of the sukuk. For non-recourse asset-backed sukuk, pricing is based on the asset. For sukuk structured based on fixed income and debt-creating contracts, pricing is typically similar to bond pricing.
Sale of debt	**Tradability**	Dependent on the nature of underlying assets

Methodology: Diagnostics, forecast techniques & variable screening

Model diagnostics

Augmented Dickey-Fuller:

$$\Delta y_t = \alpha + \beta t + \phi y_{t-1} + \sum_{i=1}^{p} \psi_i \Delta y_{t-i} + \varepsilon_t$$

Kwiatkowski-Phillips-Schmidt-Shin:

$$S_t = \sum_{i=1}^{t} \hat{u}_i$$

$$KPSS = \frac{1}{T^2 \hat{\sigma}_u^2} \sum_{t=1}^{T} S_t^2$$

Ljung-Box portmanteau Q:

$$Q(m) = n(n+2) \sum_{k=1}^{m} \frac{\hat{p}_k^2}{n-k}$$

Akaike/Bayesian Info Criterion:

$$\text{AIC} = -2\hat{\ell} + 2k$$
$$\text{BIC} = -2\hat{\ell} + k \ln n$$

MASE (scale-free), benchmarked to seasonal naïve with s = 12:

$$MASE = \frac{\frac{1}{H}\sum_{t=1}^{H} |y_t - \hat{y}_t|}{\frac{1}{T-s}\sum_{t=s+1}^{T} |y_t - y_{t-s}|}$$

- **ADF-KPSS triangulation: In first differences, n**on-rejection for ADF, vice-versa for KPSS renders *d* = 1
- **Seasonality and residual whiteness:** Seasonal unit-root behaviour, but no autocorrelation at m=12/24
- **Parsimonious model:** Lower AIC/BIC preferred, BIC imposes stronger penalty, promoting more stable models
- **Scale-free accuracy:** MASE < 1 means the model is better the seasonal naïve forecast at s = 12

Main forecasting technique

Seasonal Autoregressive Integrated Moving Average (SARIMA):
AR: $\Phi(B) = 1 - \phi_1 B - \cdots - \phi_p B^p$, $\Phi_s(B^s) = 1 - \Phi_1 B^s - \cdots - \Phi_P B^{P_s}$

MA: $\Theta(B) = 1 + \theta_1 B + \cdots + \theta_q B^q$, $\Theta_s(B^s) = 1 + \Theta_1 B^s + \cdots + \Theta_Q B^{Q_s}$

No intercept/drift retained in the selected specification

SARIMA with exogenous variable (SARIMAX): Let Z_{t-1} be the lag-1 standardized exogenous vector:

$$Z_{t-1} = [MGS10Y_{t-1}, OPR_{t-1}, FD_{t-1}, FX_{t-1}, QGDP_{t-1}, Bond\ D_{t-1}, Bond\ S_{t-1}]'$$

Overall model with no intercept: $w_t = \beta' Z_{t-1} + u_t,\ u_t = \theta(B)\Theta(B^{12})\varepsilon_t$

- **Chosen baseline:** SARIMA (0,1,2)(0,1,1)$_{12}$, implying no AR terms, $d = 1, D = 1$, two non-seasonal MA terms, one seasonal MA terms
- **Residual diagnostics**: Ljung-Box tests at 12 and 24 check whether residual correlation remains after fitting
- **Regressand**: Sukuk demand and sukuk supply, transformed as : $w_t = (1-B)(1-B^{12})y_t$
- **SARIMAX regressors:** TY MWALD-selected variables enter with 1-month lag, standardised using training-window mean and standard deviation

Model-agnostic directionality screening

Augmented VAR in levels (avoid pretest bias):

$$Z_t = c + \sum_{i=1}^{k+d_{max}} A_i Z_{t-i} + u_t$$

Test restrictions only on first k lags; additional d_{max} lags are included but untested

Modified Wald statistics (valid with unit roots/cointegration):

$$W = R(\hat{\beta} - r)' \left[R\widehat{Var}(\hat{\beta})R'\right)^{-1}[R(\hat{\beta}) - r] \sim \chi_q^2$$

- **Candidate pool:** OPR*, 12M fixed deposits rate by commercial banks, quarterly GDP growth, 10-year MGS yield, conventional bond demand, conventional bonds supply, USD/MYR rate, FBM KLCI, FDI inflow, FDI outflow, FDI net flow
- **Toda-Yamamoto Modified Wald Test (TY MWALD) screening** – identify variables with predictive directional content for sukuk demand-supply
- **Retained SARIMAX drivers:** OPR, 12M FD rate, Quarterly GDP growth, 10MGSY, conventional bond demand, conventional bond supply, USD/MYR

**Latest data is mid-2004; other variables are dated since 2000.*

Methodology: Establishing forecast baseline and determining external factors

SARIMA as baseline forecast model

- Baseline model for Seasonal Autoregressive Integrated Moving Average (SARIMA): (p, d, q)(P, D, Q)h = $(0,1,2)(0,1,1)_{12}$
- Seasonal differencing and Moving Average (MA) terms are applied.
- $c \neq 0$, no intercept/drift as it would act like a deterministic trend. After differencing, the series fluctuates around zero without imposed drift.

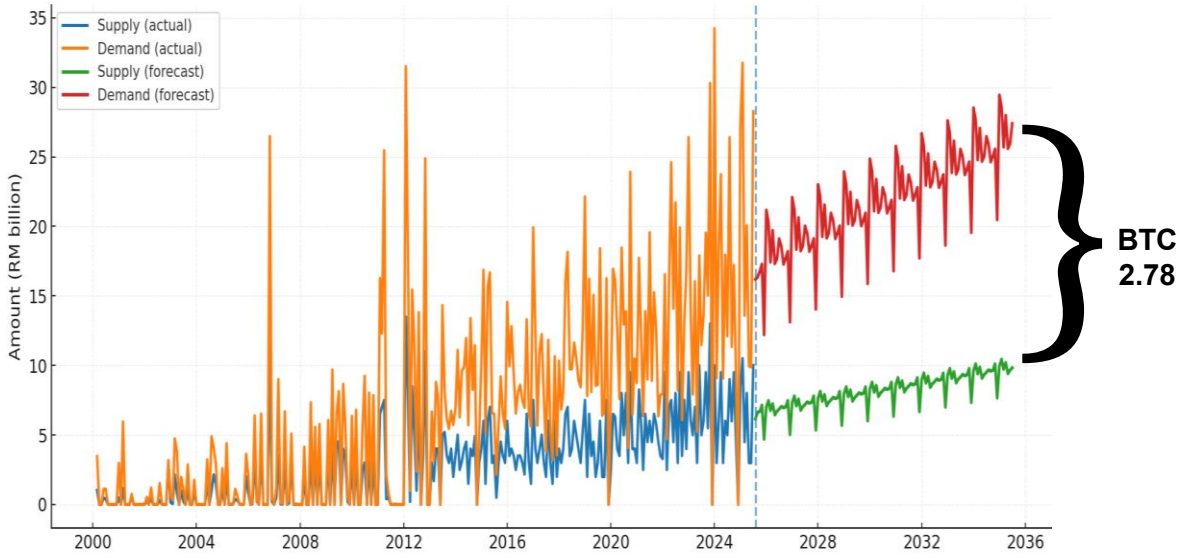
Observations:

a) Sukuk bid-to-cover (BTC) under SARIMA forecast shows constant value of 2.78 throughout 5-year and 10-year forecast horizon.

b) Mean Absolute Scaled Error (MASE) for both Supply and Demand > 1 (1.41, 1.58 respectively). This means its forecast is worse than seasonal naïve benchmark.

c) Refinement is needed, leading to utilisation of TY-MWALD to consider for exogeneity.

Baseline forecast for sukuk issuance supply-demand



Choosing external factors via Toda-Yamamoto Modified Wald Test

Exogenous variables tested and accepted

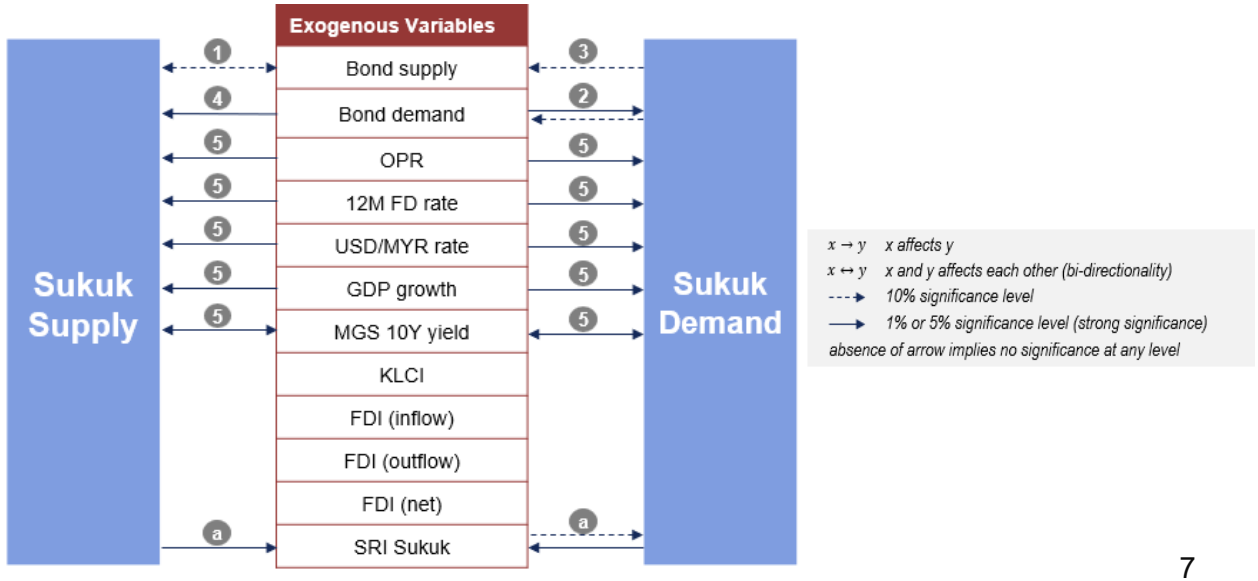
1. Sukuk and bond supply affects each other, since the supply of one may prompt adjustment in the other.
2. Similarly on the demand side, sukuk and bond demand affect each other, since a surge in demand for one may lead to rebalancing away from the other.
3. Sukuk demand affects bond supply, potentially due to strong investor preference for Shariah-compliant instruments influencing bond issuers to reduce issuance of bond.
4. Bond demand affects Islamic supply, likely since conventional bond buyers are also able to buy sukuk, causes spillover to sukuk market and influence sukuk supply decision.
5. Other variables are well expected to strongly affect both sukuk supply and demand, i.e. OPR, FD rate, FX rate, GDP growth & benchmark MGS 10Y yield. Strong bi-directionality in MGS 10Y yield.

Exogenous variable tested and accepted, but unable to be applied

a. SRI Sukuk to influence Sukuk demand, while being affected by both Sukuk demand and supply. To be excluded due to severe data limitation (dataset starts from 2017, while others from 2000).

Exogenous variables tested and rejected

KLCI and FDI (tested individually for inflow, outflow and net) are not significant variables.

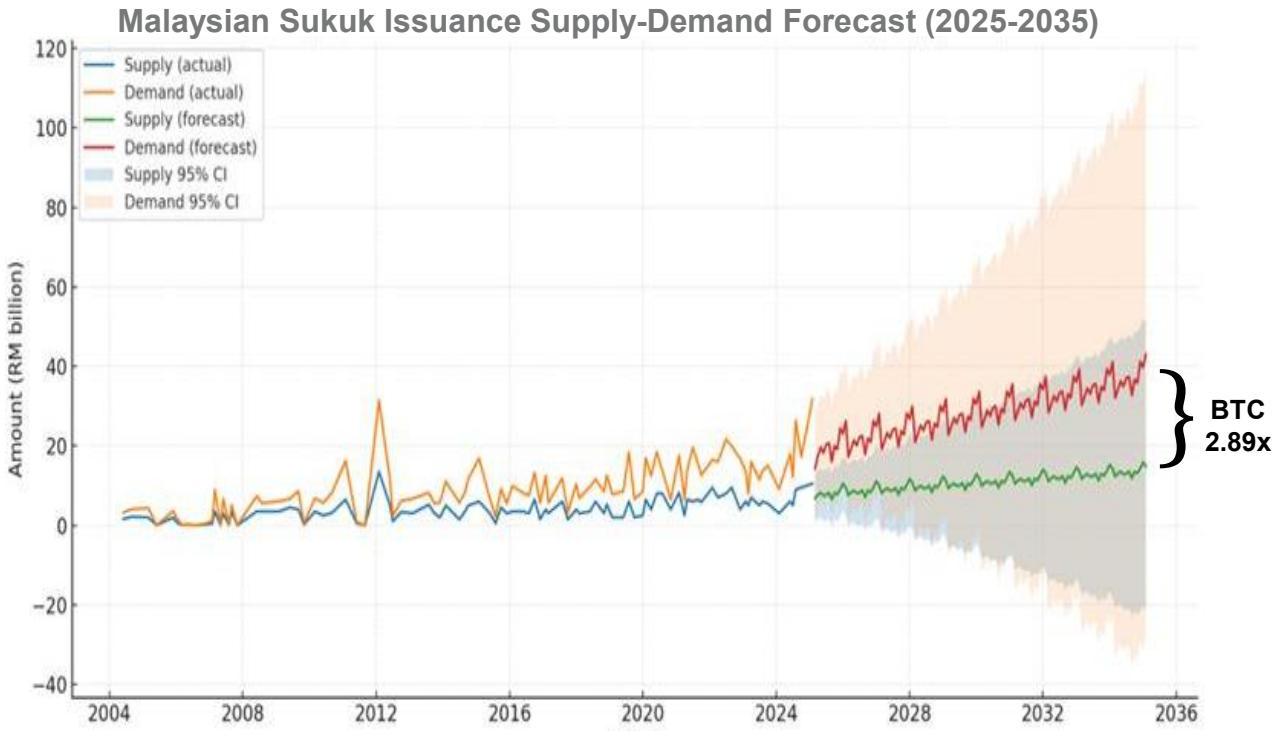


Analysis: Demand for Malaysia's sukuk forecasted to triple in the next decade, widening existing demand-supply gap

Model equation

$$w_t = \beta' Z_{t-1} + \theta(B)\Theta(B^{12})\varepsilon_t$$

$$Z_{t-1} = [MGS10Y_{t-1}, OPR_{t-1}, FD_{t-1}, FX_{t-1}, QGDP_{t-1}, Bond\ D_{t-1}, Bond\ S_{t-1}]'$$



- Accuracy metric: MASE value for Supply and Demand are 0.896, 0.885. This means that the model's average error is smaller than the naïve baseline.
- The same model applies with seasonal differencing (D=1, s=12) and non-seasonal differencing (d=1)
- Ljung-Box at 12 and 24 lags are insignificant, signifying no residual autocorrelation.
- Exogenous variables are all standardised, lagged by 1 month

Findings

1. **Accelerating demand** – Demand for Ringgit-denominated sukuk is projected to triple to RM42 billion by 2035, with highest estimate to go beyond RM100 billion. In contrast, demand for bonds is expected to moderate during the same period.
2. **Widening demand-supply gap** – Demand growth will further outpace supply, with bid-to-cover ratio (BTC) forecasted to rise to 2.89x by 2035 (2025: 2.10x). This signals increasing competition among investors for limited Shariah-compliant sukuk issuances.
3. **Forecast incorporates exogenous variables** such as OPR, GDP growth, benchmark 10Y MGS yield, conventional bonds demand & supply, 12M fixed deposits rate by commercial banks, USD/MYR exchange rate. The exogenous variables are adding genuine predictive signal to the differenced mean.
4. **Accuracy metric**: MASE value for Supply and Demand are 0.896, 0.885. Reflecting model's average error to be smaller than naïve baseline.

Supportive anecdotal evidence

Growing appetite from sizeable domestic institutional investors with Shariah-compliant investment mandate. For example, Malaysia's Employee Provident Fund (EPF) – ranked as the 13th largest pension fund globally and 5th in Asia – recorded an 11% increase in total contribution driven by wage growth, among others.

Analysis: Coefficients of the exogenous variables

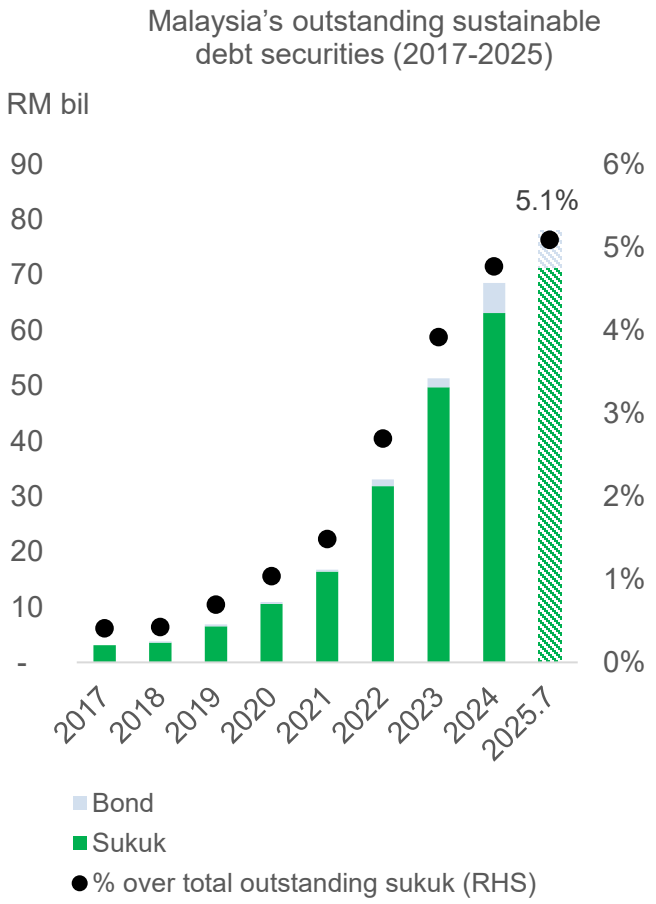
Dependent Variable	Scenario-Unit Impact	Exogenous Variable	Scenario-Unit Impact	Dependent Variable
Sukuk supply	+ RM2.18 bn	**Bond supply (+RM10 bn)**	+ RM4.95 bn	**Sukuk Demand**
	+ RM0.25 bn	**Bond demand (+RM10 bn)**	+ RM0.33 bn	
	+ RM0.77 bn	**OPR (+25 bps)**	+ RM1.10 bn	
	- RM2.68 bn	**12M FD rate (+25 bps)**	- RM5.17 bn	
	+ RM0.36 bn	**USD/MYR rate (+0.10 USD appreciates)**	+ RM0.89 bn	
	+ RM0.12 bn	**GDP growth (+ 1.0 pps)**	+ RM0.30 bn	
	- RM0.82 bn	**MGS 10Y yield (+ 50 bps)**	- RM1.33 bn	

Observations:

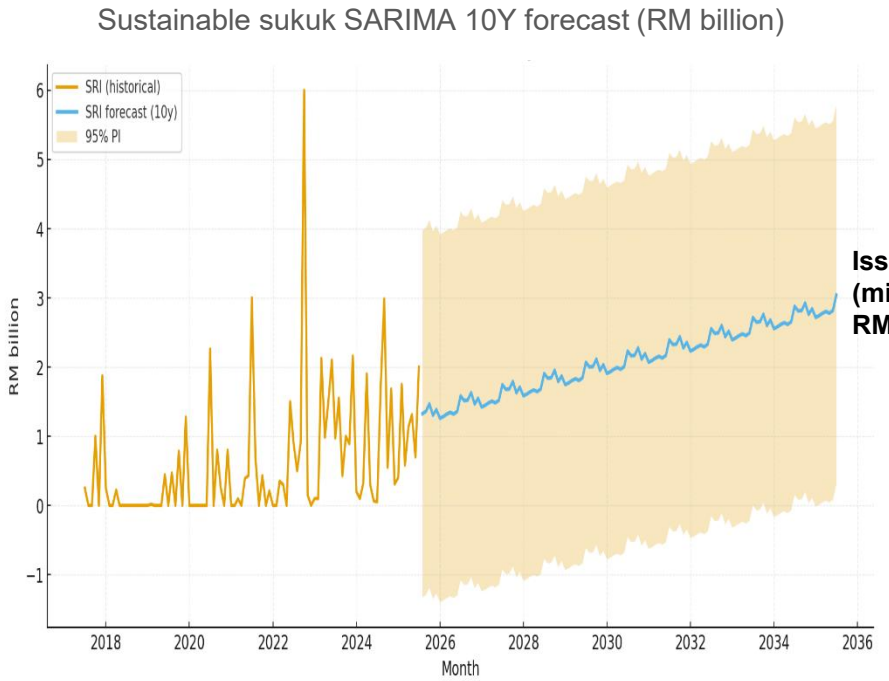
1. **Increasing rates in 12 Month Fixed Deposit rate and MGS 10-year yield** would **impact negatively** on sukuk demand and sukuk supply.
    a) When yields rise, existing bonds with lower coupons become less attractive causing their price to fall. Investors may hold off buying sukuk, expecting better yields (and lower prices) in the near future.
    b) Increase in 12M Fixed Deposit rate offers investors alternatives with higher returns, hence reducing sukuk demand as well as supply
2. **Higher GDP growth** reflects a robust and expanding economy, which boosts business confidence. This economic optimism encourages both companies to issue sukuk for expansion and infrastructure financing (increasing supply) and investors to seek such instruments as a stable, Shariah-compliant investment option (increasing demand).
3. **An increasing OPR** typically indicates a tightening monetary policy environment in response to inflationary concerns. This can lead to higher benchmark yields, making sukuk relatively more attractive as they may offer competitive returns in line with overall market expectations. Consequently, investors will be more inclined to invest, driving both supply and demand upward.
4. **Weaker MYR against USD** may expose companies to higher foreign exchange risks and increased costs in international transactions, prompting them to seek alternative financing options like sukuk to better manage their funding needs.

Analysis: Sustainable sukuk could bridge the expected demand-supply gap

Rapid growth of sustainable sukuk[1] (5Y CAGR: 57%)



Forecasted issuance of sustainable sukuk in 10 years is sufficient to plug the projected demand-supply gap[2] (RM2.95 bil)



Issuance size (mid-2035): RM3.04b

Multiple drivers are expected to maintain momentum in sustainable sukuk growth

Alignment with national agenda (e.g. National Energy Transition Roadmap, New Industrial Master Plan 2030)

Facilitative regulatory landscape (e.g. tax incentives, issuance of industry guidance)

Enhanced integration of ESG into investors' strategy & mandate

Broader range of issuers

[1] Sustainable sukuk include Sustainable and Responsible Investment (SRI) and SRI-linked sukuk as outlined by Securities Commission Malaysia and ASEAN Green, Social, Sustainability and Sustainability-linked Bond as outlined by ASEAN Capital Market Forum (ACMF)
[2] Demand-supply gap refers to difference in forecasted BTC (2.89x) and 20-year average BTC (2.41x)

Challenges and limitations: Considerations for other future studies

Limitations	Description
A **Inconsistency in sukuk issuance data frequency**	Inconsistent monthly sukuk issuance, where there were zero issuance in several months, which can impact the robustness of forecasts. Forecasting models rely on consistent data patterns to make accurate predictions.
B **Severely limited time horizon for sustainable sukuk**	Sustainable sukuk was only first issued in 2017, compared to the overall sukuk dataset that are available from early 21st century. Its limited data timeline renders it incompatible with the overall SARIMAX model.
C **Sustainable sukuk is on private placement only**	Sustainable sukuk is currently offered exclusively through private placement, which renders its exclusion from the overall sukuk forecast.
D **Limited benchmarking on sukuk issuance forecasting**	There are limited studies conducted on forecasting of sukuk in both industry and academia. This gap underscores the need for more rigorous research and data-driven analysis to establish benchmarks and improve predictive methodologies in the sukuk market.

Conclusion

1. Sukuk demand in Malaysia is forecasted to triple within the next decade, expected to widen the demand-supply gap and increase competition among investors seeking for the Shariah-compliant investment instrument.

    - Seasonal Autoregressive Integrated Moving Average (SARIMA) is inadequate to project the forecast accurately, hence necessitating exogenous variables in the said projection (SARIMAX).
    - Incorporated exogenous variables include conventional bonds supply and demand, Overnight Policy Rate, 12-month fixed deposit rate by commercial banks, USD-MYR exchange rate, quarterly GDP growth and Malaysian Government Securities (MGS) 10-year yield.
    - Anecdotal evidences are also supportive, with expectation of growing appetite from major institutional investors with Shariah-compliant mandate e.g. Malaysia's Employee Provident Fund (EPF) recorded 11% increase in contribution size.

2. Sustainable sukuk growth is rapid in Malaysia. The segment could bridge the demand-supply gap within the same period, if growth continues.

    - Supported by multiple drivers such as facilitative regulatory support and alignment with national agenda such as Malaysia's National Energy Transition Roadmap and New Industrial Master Plan 2030. Malaysia commits to achieving net zero by 2050.

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Thank you!

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Appendices

Literature review

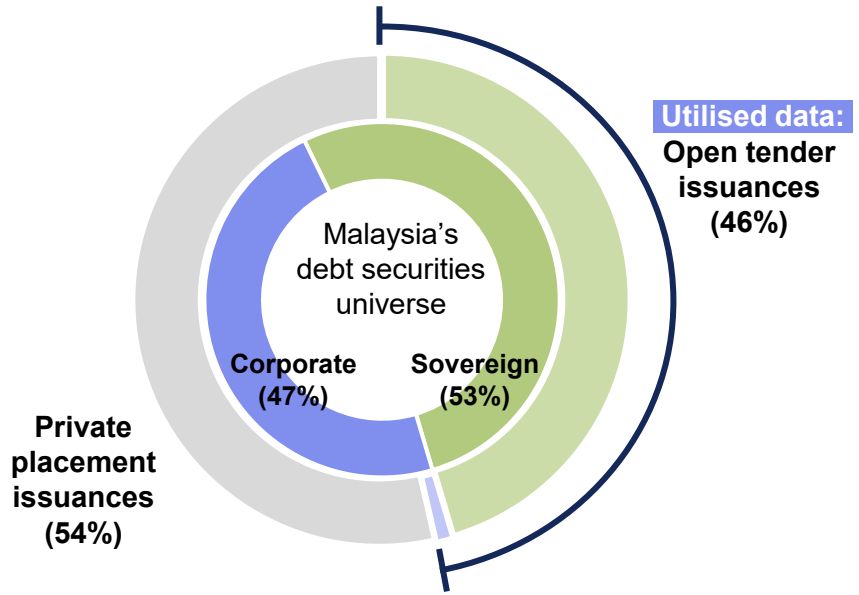
A. Sukuk industry in Malaysia

- **Foundational insights:** Sukuk is the Arabic term for Islamic securities, it simply means certificate. Sukuk is documented as a tool for resource mobilisation (Jobst, Kunzel, Mills & Sy, 2008). Sukuk tend to be structured so the end economic result mimic fixed income instrument such as bond with similar risk-reward structures and features, since bond market plays pivotal roles in the economy and financial markets (Bahari et al., 2016, Sairally et al., 2017).
- **Development and evolution of sukuk**: Early experiences in Malaysia was initiated by the Government of Malaysia by issuing Government Investment Certificate (GIC) in 1983 to provide avenue for short-term liquidity management and long-term investment for Islamic financial institutions during the period. First corporate sukuk was later issued in Malaysia in 1990 by Shell MDS Malaysia Sdn Bhd (Sairally et al., 2017). Malaysia's sukuk is known to finance its domestic infrastructure projects, though the market has structured sukuk to suit variety of specific funding needs of various economic activities for example sale-based sukuk (based on the concept of *Murabahah, Salam, Istisna*), lease-based sukuk (based on the concept of *Ijarah*), partnership-based and agency (based on the concept of *Mudarabah/Musharakah* and *Wakalah*), or any combination thereof. Further innovation introduces capacity sukuk, utilising 'business capacity' of respective companies (such as airtime by telcos, right to travel by airlines) as intangible underlying assets (Djafri et al., 2023).
- **Malaysia's sukuk market:** Malaysia's sukuk market has grown exponentially and even demonstrating positive impact to the Malaysia's economic growth (Abrorov, 2020). Malaysia provides as an ideal dataset for this study, hosting a matured sukuk market under the dual financial system alongside the conventional bond market, enabling fair comparison against between the two vibrant, deep markets.

B. Forecast model

- **ARIMA as a baseline:** Many studies start with ARIMA to establish a benchmark forecast for sukuk or related financial series [Rosadhillah & Ülev, 2024]. It captures autoregressive structure but is limited in scope. Our use of ARIMA as an initial step aligns with common practice and provides a yardstick for improvements.
- **ARIMAX with Causality-based Inputs in Sukuk:** Incorporating exogenous macro drivers is advised by numerous researchers. Empirical results show that including relevant variables (e.g. interest rates, inflation) can enhance forecast accuracy for sukuk, such as the case in Malaysia and Turkiye [Humaida, Nur Atikah and Dini Naziha, 2016; Baykut, 2024]. By using the Toda-Yamamoto causality test (as in Baykut, 2024) to guide variable selection, we ensure our ARIMAX model only includes factors that have proven predictive content for sukuk. This evidence-driven ARIMAX is likely to outperform a pure ARIMA, as supported by findings in other domains where ARIMAX was preferred for greater accuracy [Paul & Sinha, 2016]. Essentially, our approach combined ARIMA forecasting with Toda-Yamamoto Modified Wald Test for sukuk and macroeconomic variables.
- **Machine Learning to Rival Econometric Models: I**ntegration of machine learning techniques with time-series models. Zainuddin et al. (2019) and Çetin & Metlek (2024) examined sukuk investment forecasts using a hybrid of classical moving-average and artificial neural network (ANN) algorithms; they found that a purely statistical moving average (MA) model produced biased estimates for sukuk prices/indices, whereas the proposed ANN-enhanced approach significantly reduced forecast errors. This result underlines a broader point: while linear models like ARIMA/ARDL capture baseline patterns, non-linear or complex patterns might be better handled by machine learning. Other studies in Islamic finance have likewise started comparing traditional models to newer methods (e.g. comparing ARIMA/ARIMAX to deep learning or recurrent networks for financial series) [Elbatal et al., 2025]. In general, these studies show that baseline ARIMA or regression models often benefit from either including exogenous inputs or combining with non-linear learners to capture all dynamics.

Dataset and assumptions



Why open tender issuance data?

Market-driven indicator | **Market benchmark** | **Significant size**

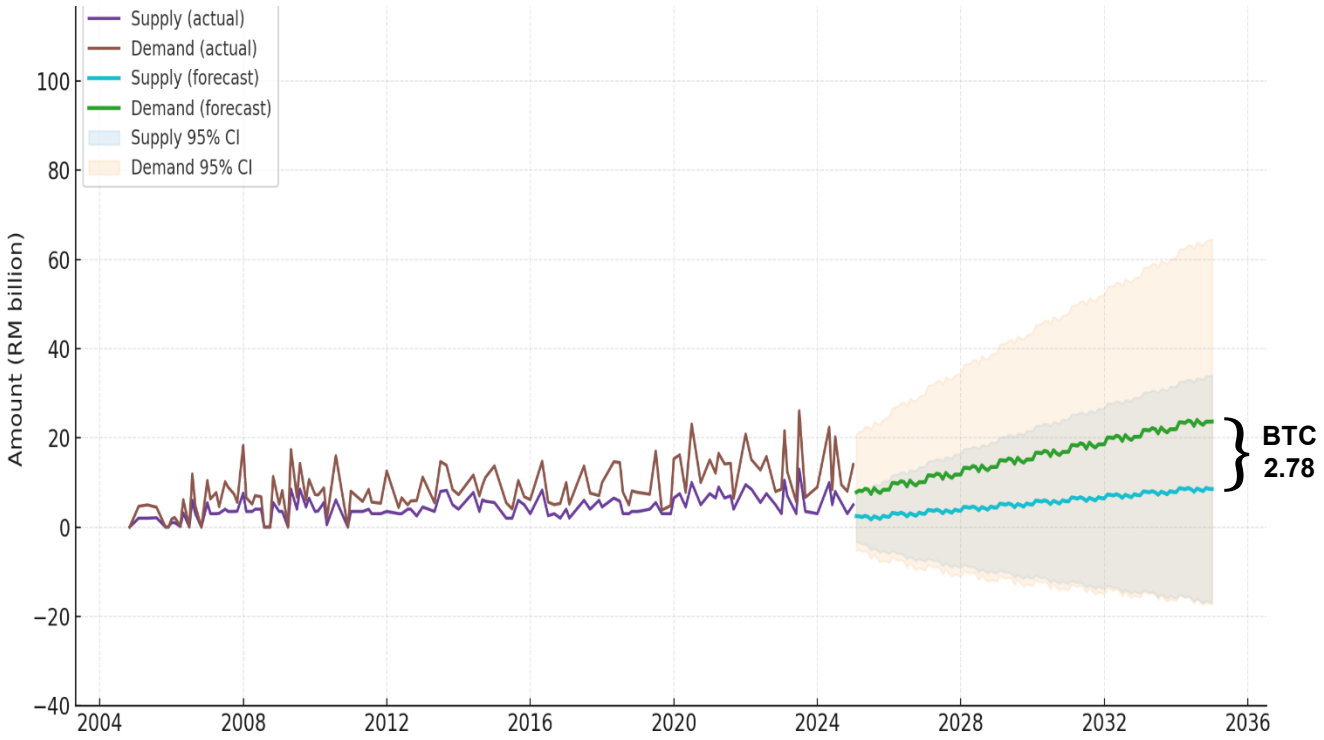
Dataset comprises of 869 issuances from Jan 2000-July 2025, offering a balanced representation across categories

- 655 sovereign issuances (by BNM, GOM) and 214 corporate issuances (from entities such as Khazanah, Cagamas, TNB, Telekom)
- 491 conventional bonds, 378 Shariah-compliant sukuk

General forecast assumptions

Stable political and policy environment	No policy reversal or regulatory changes that could drastically shock the financial market. This includes Shariah regulations.
No black swan events	No major unforeseen disruptions such as global financial crisis or geopolitical conflicts
Continued growth, stable monetary policy	Economic growth and policy rate follows a historically predictable path; OPR are within range of 1.75%-3.50%
Consistent non-resident	Non-resident holdings remains low (average 3.6% over outstanding), following historical trajectory. Forecast excludes potential upside from increased non-resident interest arising from latest efforts to attract foreign investors
Data aggregation	Issuances are aggregated into monthly data, irrespective of tenor, to ensure analytical viability

Conventional bond forecast: Bond demand is expected to moderate amid accelerating demand for sukuk



Model diagnostics

- The same model is applied for forecasting bond $(0, 1, 2)(0,1,1)_{12}$
- Exogenous variables: OPR, 12-month FD rate, FX rate, Quarterly GDP growth, MGS 10-year yield, Islamic demand and supply
- MASE value for Conventional Supply and Demand are 0.68, 0.71 respectively. In terms of accuracy metrics, the model's error are smaller than the naïve benchmark.
- The exogenous variables are adding **genuine predictive signal** to the differenced mean.

Findings

- Islamic demand outpacing conventional demand – beyond 1.70x
- Closing demand-supply gap – Demand growth will decline towards meeting supply, with bid-to-cover ratio (BTC) forecasted to drop to 2.78x by 2035 (2025: 3.19x). This might entail possible shift to Islamic bonds in the long-term.